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(54) Title: MATERIALS AND METHODS FOR THE MODIFICATION OF PLANT LIGNIN CONTENT (57) Abstract Novel isolated DNA sequences associated with the lignin biosynthetic pathway are provided, together with DNA constructs including such sequences. Methods for the modulation of lignin content in plants are also disclosed, the methods comprising incorporating one or more of the inventive DNA sequences or a sequence complementary to an inventive DNA sequence into the genome of a plant.		

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MATERIALS AND METHODS FOR THE MODIFICATION OF PLANT LIGNIN CONTENT

5 Technical Field of the Invention

This invention relates to the field of modification of lignin content and composition in plants. More particularly, this invention relates to enzymes involved in the lignin biosynthetic pathway and nucleotide sequences encoding such enzymes.

10 Background of the Invention

Lignin is an insoluble polymer which is primarily responsible for the rigidity of plant stems. Specifically, lignin serves as a matrix around the polysaccharide components of some plant cell walls. The higher the lignin content, the more rigid the plant. For example, tree species synthesize large quantities of lignin, with lignin
15 constituting between 20% to 30% of the dry weight of wood. In addition to providing rigidity, lignin aids in water transport within plants by rendering cell walls hydrophobic and water impermeable. Lignin also plays a role in disease resistance of plants by impeding the penetration and propagation of pathogenic agents.

The high concentration of lignin in trees presents a significant problem in the
20 paper industry wherein considerable resources must be employed to separate lignin from the cellulose fiber needed for the production of paper. Methods typically employed for the removal of lignin are highly energy- and chemical-intensive, resulting in increased costs and increased levels of undesirable waste products. In the U.S. alone, about 20 million tons of lignin are removed from wood per year.

25 Lignin is largely responsible for the digestibility, or lack thereof, of forage crops, with small increases in plant lignin content resulting in relatively high decreases in digestibility. For example, crops with reduced lignin content provide more efficient forage for cattle, with the yield of milk and meat being higher relative to the amount of forage crop consumed. During normal plant growth, the increase in dry matter content
30 is accompanied by a corresponding decrease in digestibility. When deciding on the optimum time to harvest forage crops, farmers must therefore chose between a high yield of less digestible material and a lower yield of more digestible material.

For some applications, an increase in lignin content is desirable since increasing the lignin content of a plant would lead to increased mechanical strength of wood, changes in its color and increased resistance to rot. Mycorrhizal species composition and abundance may also be favorably manipulated by modifying lignin content and structural composition.

As discussed in detail below, lignin is formed by polymerization of at least three different monolignols which are synthesized in a multistep pathway, each step in the pathway being catalyzed by a different enzyme. It has been shown that manipulation of the number of copies of genes encoding certain enzymes, such as cinnamyl alcohol dehydrogenase (CAD) and caffeic acid 3-O-methyltransferase (COMT) results in modification of the amount of lignin produced; see, for example, U.S. Patent No. 5,451,514 and PCT publication no. WO 94/23044. Furthermore, it has been shown that antisense expression of sequences encoding CAD in poplar leads to the production of lignin having a modified composition (Grand, C. et al. Planta (Berl.) 163:232-237 (1985)).

While DNA sequences encoding some of the enzymes involved in the lignin biosynthetic pathway have been isolated for certain species of plants, genes encoding many of the enzymes in a wide range of plant species have not yet been identified. Thus there remains a need in the art for materials useful in the modification of lignin content and composition in plants and for methods for their use.

Summary of the Invention

Briefly, the present invention provides isolated DNA sequences obtainable from eucalyptus and pine which encode enzymes involved in the lignin biosynthetic pathway, DNA constructs including such sequences, and methods for the use of such constructs. Transgenic plants having altered lignin content and composition are also provided.

In a first aspect, the present invention provides isolated DNA sequences coding for the following enzymes isolated from eucalyptus and pine: cinnamate 4-hydroxylase (C4H), coumarate 3-hydroxylase (C3H), phenolase (PNL), O-methyl transferase (OMT), cinnamyl alcohol dehydrogenase (CAD), cinnamoyl-CoA reductase (CCR), phenylalanine ammonia-lyase (PAL), 4-coumarate:CoA ligase (4CL), coniferol

glucosyl transferase (CGT), coniferin *beta*-glucosidase (CBG), laccase (LAC) and peroxidase (POX), together with ferulate-5-hydroxylase (F5H) from eucalyptus. In one embodiment, the isolated DNA sequences comprise a nucleotide sequence selected from the group consisting of: (a) sequences recited in SEQ ID NO: 3, 13, 16-70, and 72-88; (b) complements of the sequences recited in SEQ ID NO: 3, 13, 16-70, 72-88; (c) reverse complements of the sequences recited in SEQ ID NO: 3, 13, 16-70, 72-88; (d) reverse sequences of the sequences recited in SEQ ID NO: 3, 13, 16-70, 72-88; and (e) sequences having at least about a 99% probability of being the same as a sequence of (a) – (d) as measured by the computer algorithm FASTA.

In another aspect, the invention provides DNA constructs comprising a DNA sequence of the present invention, either alone, in combination with one or more of the inventive sequences or in combination with one or more known DNA sequences; together with transgenic cells comprising such constructs.

In a related aspect, the present invention provides DNA constructs comprising, in the 5'-3' direction, a gene promoter sequence; an open reading frame coding for at least a functional portion of an enzyme encoded by the inventive DNA sequences or variants thereof; and a gene termination sequence. The open reading frame may be orientated in either a sense or antisense direction. DNA constructs comprising a non-coding region of a gene coding for an enzyme encoded by the above DNA sequences or a nucleotide sequence complementary to a non-coding region, together with a gene promoter sequence and a gene termination sequence, are also provided. Preferably, the gene promoter and termination sequences are functional in a host plant. Most preferably, the gene promoter and termination sequences are those of the original enzyme genes but others generally used in the art, such as the Cauliflower Mosaic Virus (CMV) promoter, with or without enhancers, such as the Kozak sequence or Omega enhancer, and *Agrobacterium tumefaciens* nopaline synthase terminator may be usefully employed in the present invention. Tissue-specific promoters may be employed in order to target expression to one or more desired tissues. In a preferred embodiment, the gene promoter sequence provides for transcription in xylem. The DNA construct may further include a marker for the identification of transformed cells.

In a further aspect, transgenic plant cells comprising the DNA constructs of the present invention are provided, together with plants comprising such transgenic cells, and fruits and seeds of such plants.

In yet another aspect, methods for modulating the lignin content and composition of a plant are provided, such methods including stably incorporating into the genome of the plant a DNA construct of the present invention. In a preferred embodiment, the target plant is a woody plant, preferably selected from the group consisting of eucalyptus and pine species, most preferably from the group consisting of *Eucalyptus grandis* and *Pinus radiata*. In a related aspect, a method for producing a plant having altered lignin content is provided, the method comprising transforming a plant cell with a DNA construct of the present invention to provide a transgenic cell, and cultivating the transgenic cell under conditions conducive to regeneration and mature plant growth.

In yet a further aspect, the present invention provides methods for modifying the activity of an enzyme in a plant, comprising stably incorporating into the genome of the plant a DNA construct of the present invention. In a preferred embodiment, the target plant is a woody plant, preferably selected from the group consisting of eucalyptus and pine species, most preferably from the group consisting of *Eucalyptus grandis* and *Pinus radiata*.

The above-mentioned and additional features of the present invention and the manner of obtaining them will become apparent, and the invention will be best understood by reference to the following more detailed description, read in conjunction with the accompanying drawing.

Brief Description of the Figures

Fig. 1 is a schematic overview of the lignin biosynthetic pathway.

Detailed Description

Lignin is formed by polymerization of at least three different monolignols, primarily *para*-coumaryl alcohol, coniferyl alcohol and sinapyl alcohol. While these three types of lignin subunits are well known, it is possible that slightly different variants of these subunits may be involved in the lignin biosynthetic pathway in various

plants. The relative concentration of these residues in lignin varies between different plant species and within species. In addition, the composition of lignin may also vary between different tissues within a specific plant. The three monolignols are derived from phenylalanine in a multistep process and are believed to be polymerized into lignin by a free radical mechanism.

Fig. 1 shows the different steps in the biosynthetic pathway for coniferyl alcohol together with the enzymes responsible for catalyzing each step. *para*-Coumaryl alcohol and sinapyl alcohol are synthesized by similar pathways. Phenylalanine is first deaminated by phenylalanine ammonia-lyase (PAL) to give cinnamate which is then hydroxylated by cinnamate 4-hydroxylase (C4H) to form *p*-coumarate. *p*-Coumarate is hydroxylated by coumarate 3-hydroxylase to give caffeate. The newly added hydroxyl group is then methylated by O-methyl transferase (OMT) to give ferulate which is conjugated to coenzyme A by 4-coumarate:CoA ligase (4CL) to form feruloyl-CoA. Reduction of feruloyl-CoA to coniferaldehyde is catalyzed by cinnamoyl-CoA reductase (CCR). Coniferaldehyde is further reduced by the action of cinnamyl alcohol dehydrogenase (CAD) to give coniferyl alcohol which is then converted into its glucosylated form for export from the cytoplasm to the cell wall by coniferol glucosyl transferase (CGT). Following export, the de-glucosylated form of coniferyl alcohol is obtained by the action of coniferin *beta*-glucosidase (CBG). Finally, polymerization of the three monolignols to provide lignin is catalyzed by phenolase (PNL), laccase (LAC) and peroxidase (POX).

The formation of sinapyl alcohol involves an additional enzyme, ferulate-5-hydroxylase (F5H). For a more detailed review of the lignin biosynthetic pathway, see: Whetton, R. and Sederoff, R., The Plant Cell, 7:1001-1013 (1995).

Quantitative and qualitative modifications in plant lignin content are known to be induced by external factors such as light stimulation, low calcium levels and mechanical stress. Synthesis of new types of lignins, sometimes in tissues not normally lignified, can also be induced by infection with pathogens. In addition to lignin, several other classes of plant products are derived from phenylalanine, including flavonoids, coumarins, stilbenes and benzoic acid derivatives, with the initial steps in the synthesis of all these compounds being the same. Thus modification of the action of PAL, C4H and 4CL may affect the synthesis of other plant products in addition to lignin.

Using the methods and materials of the present invention, the lignin content of a plant can be increased by incorporating additional copies of genes encoding enzymes involved in the lignin biosynthetic pathway into the genome of the target plant. Similarly, a decrease in lignin content can be obtained by transforming the target plant with antisense copies of such genes. In addition, the number of copies of genes encoding for different enzymes in the lignin biosynthetic pathway can be manipulated to modify the relative amount of each monolignol synthesized, thereby leading to the formation of lignin having altered composition. The alteration of lignin composition would be advantageous, for example, in tree processing for paper, and may also be effective in altering the palatability of wood materials to rotting fungi.

In one embodiment, the present invention provides isolated complete or partial DNA sequences encoding, or partially encoding, enzymes involved in the lignin biosynthetic pathway, the DNA sequences being obtainable from eucalyptus and pine. Specifically, the present invention provides isolated DNA sequences encoding the enzymes CAD (SEQ ID NO: 1, 30), PAL (SEQ ID NO: 16), C4H (SEQ ID NO: 17), C3H (SEQ ID NO: 18), F5H (SEQ ID NO: 19-21), OMT (SEQ ID NO: 22-25), CCR (SEQ ID NO: 26-29), CGT (SEQ ID NO: 31-33), CBG (SEQ ID NO: 34), PNL (SEQ ID NO: 35, 36), LAC (SEQ ID NO: 37-41) and POX (SEQ ID NO: 42-44) from *Eucalyptus grandis*; and the enzymes C4H (SEQ ID NO: 2, 3, 48, 49), C3H (SEQ ID NO: 4, 50-52), PNL (SEQ ID NO: 5, 81), OMT (SEQ ID NO: 6, 53-55), CAD (SEQ ID NO: 7, 71), CCR (SEQ ID NO: 8, 58-70), PAL (SEQ ID NO: 9-11, 45-47), 4CL (SEQ ID NO: 12, 56, 57), CGT (SEQ ID NO: 72), CBG (SEQ ID NO: 73-80), LAC (SEQ ID NO: 82-84) and POX (SEQ ID NO: 13, 85-88) from *Pinus radiata*. Complements of such isolated DNA sequences, reverse complements of such isolated DNA sequences and reverse sequences of such isolated DNA sequences, together with variants of such sequences, are also provided. DNA sequences encompassed by the present invention include cDNA, genomic DNA, recombinant DNA and wholly or partially chemically synthesized DNA molecules.

The definition of the terms "complement", "reverse complement" and "reverse sequence", as used herein, is best illustrated by the following example. For the sequence 5' AGGACC 3', the complement, reverse complement and reverse sequence are as follows:

complement	3' TCCTGG 5'
reverse complement	3' GGTCCT 5'
reverse sequence	5' CCAGGA 3'.

As used herein, the term "variant" covers any sequence which exhibits at least about 50%, more preferably at least about 70% and, more preferably yet, at least about 90% identity to a sequence of the present invention. Most preferably, a "variant" is any sequence which has at least about a 99% probability of being the same as the inventive sequence. The probability for DNA sequences is measured by the computer algorithm FASTA (version 2.0u4, February 1996; Pearson W. R. et al., Proc. Natl. Acad. Sci., 85:2444-2448, 1988), the probability for translated DNA sequences is measured by the computer algorithm TBLASTX and that for protein sequences is measured by the computer algorithm BLASTP (Altschul, S. F. et al. J. Mol. Biol., 215:403-410, 1990). The term "variants" thus encompasses sequences wherein the probability of finding a match by chance (smallest sum probability) in a database, is less than about 1% as measured by any of the above tests.

Variants of the isolated sequences from other eucalyptus and pine species, as well as from other commercially important species utilized by the lumber industry, are contemplated. These include the following gymnosperms, by way of example: loblolly pine *Pinus taeda*, slash pine *Pinus elliotti*, sand pine *Pinus clausa*, longleaf pine *Pinus palustris*, shortleaf pine *Pinus echinata*, ponderosa pine *Pinus ponderosa*, Jeffrey pine *Pinus jeffrey*, red pine *Pinus resinosa*, pitch pine *Pinus rigida*, jack pine *Pinus banksiana*, pond pine *Pinus serotina*, Eastern white pine *Pinus strobus*, Western white pine *Pinus monticola*, sugar pine *Pinus lambertiana*, Virginia pine *Pinus virginiana*, lodgepole pine *Pinus contorta*, Caribbean pine *Pinus caribaea*, *P. pinaster*, Calabrian pine *P. brutia*, Afghan pine *P. eldarica*, Coulter pine *P. coulteri*, European pine *P. nigra* and *P. sylvestris*; Douglas-fir *Pseudotsuga menziesii*; the hemlocks which include Western hemlock *Tsuga heterophylla*, Eastern hemlock *Tsuga canadensis*, Mountain hemlock *Tsuga mertensiana*; the spruces which include the Norway spruce *Picea abies*, red spruce *Picea rubens*, white spruce *Picea glauca*, black spruce *Picea mariana*, Sitka spruce *Picea sitchensis*, Englemann spruce *Picea engelmanni*, and blue spruce *Picea pungens*; redwood *Sequoia sempervirens*; the true firs include the Alpine fir *Abies lasiocarpa*, silver fir *Abies amabilis*, grand fir *Abies grandis*, noble fir *Abies procera*, white fir *Abies concolor*, California red fir *Abies magnifica*, and balsam fir *Abies balsamea*, the cedars which include the Western red cedar *Thuja plicata*, incense

cedar *libocedrus decurrens*, Northern white cedar *Thuja occidentalis*, Port Orford cedar *Chamaecyparis lawsoniana*, Atlantic white cedar *Chamaecyparis thyoides*, Alaska yellow-cedar *Chamaecyparis nootkatensis*, and Eastern red cedar *Huniperus virginiana*; the larches which include Eastern larch *Larix laricina*. Western larch *Larix occidentalis*, European larch *Larix decidua*, Japanese larch *Larix leptolepis*, and Siberian larch *Larix siberica*; bold cypress *Taxodium distichum* and Giant sequoia *Sequoia gigantea*;

and the following angiosperms, by way of example:

Eucalyptus alba, *E. bancroftii*, *E. boryoides*, *E. bridgesiana*, *E. calophylla*, *E. camaldulensis*, *E. citriodora*, *E. cladocalyx*, *E. coccifera*, *E. curtisii*, *E. dalrympleana*, *E. deglupta*, *E. delagatensis*, *E. diversicolor*, *E. dunnii*, *E. ficifolia*, *E. globulus*, *E. gomphocephala*, *E. gunnii*, *E. henryi*, *E. laevopinea*, *E. macarthurii*, *E. macrorhyncha*, *E. maculata*, *E. marginata*, *E. megacarpa*, *E. melliodora*, *E. nicholii*, *E. nitens*, *E. nova-anglica*, *E. obliqua*, *E. obtusiflora*, *E. oreades*, *E. pauciflora*, *E. polybractea*, *E. regnans*, *E. resinifera*, *E. robusta*, *E. rudis*, *E. saligna*, *E. sideroxylon*, *E. stuartiana*, *E. tereticornis*, *E. torelliana*, *E. urnigera*, *E. urophylla*, *E. viminalis*, *E. viridis*, *E. wandoo* and *E. youmanni*.

The inventive DNA sequences may be isolated by high throughput sequencing of cDNA libraries such as those prepared from *Eucalyptus grandis* and *Pinus radiata* as described below in Examples 1 and 2. Alternatively, oligonucleotide probes based on the sequences provided in SEQ ID NO: 1-13 and 16-88 can be synthesized and used to identify positive clones in either cDNA or genomic DNA libraries from *Eucalyptus grandis* and *Pinus radiata*, or from other gymnosperms and angiosperms including those identified above, by means of hybridization or PCR techniques. Probes can be shorter than the sequences provided herein but should be at least about 10, preferably at least about 15 and most preferably at least about 20 nucleotides in length. Hybridization and PCR techniques suitable for use with such oligonucleotide probes are well known in the art. Positive clones may be analyzed by restriction enzyme digestion, DNA sequencing or the like.

In addition, the DNA sequences of the present invention may be generated by synthetic means using techniques well known in the art. Equipment for automated synthesis of oligonucleotides is commercially available from suppliers such as Perkin Elmer/Applied Biosystems Division (Foster City, CA) and may be operated according to the manufacturer's instructions.

In one embodiment, the DNA constructs of the present invention include an open reading frame coding for at least a functional portion of an enzyme encoded by a nucleotide sequence of the present invention or a variant thereof. As used herein, the "functional portion" of an enzyme is that portion which contains the active site essential for affecting the metabolic step, *i.e.* the portion of the molecule that is capable of binding one or more reactants or is capable of improving or regulating the rate of reaction. The active site may be made up of separate portions present on one or more polypeptide chains and will generally exhibit high substrate specificity. The term "enzyme encoded by a nucleotide sequence" as used herein, includes enzymes encoded by a nucleotide sequence which includes the partial isolated DNA sequences of the present invention.

For applications where amplification of lignin synthesis is desired, the open reading frame is inserted in the DNA construct in a sense orientation, such that transformation of a target plant with the DNA construct will lead to an increase in the number of copies of the gene and therefore an increase in the amount of enzyme. When down-regulation of lignin synthesis is desired, the open reading frame is inserted in the DNA construct in an antisense orientation, such that the RNA produced by transcription of the DNA sequence is complementary to the endogenous mRNA sequence. This, in turn, will result in a decrease in the number of copies of the gene and therefore a decrease in the amount of enzyme. Alternatively, regulation can be achieved by inserting appropriate sequences or subsequences (e.g. DNA or RNA) in ribozyme constructs.

In a second embodiment, the inventive DNA constructs comprise a nucleotide sequence including a non-coding region of a gene coding for an enzyme encoded by a DNA sequence of the present invention, or a nucleotide sequence complementary to such a non-coding region. As used herein the term "non-coding region" includes both transcribed sequences which are not translated, and non-transcribed sequences within about 2000 base pairs 5' or 3' of the translated sequences or open reading frames. Examples of non-coding regions which may be usefully employed in the inventive constructs include introns and 5'-non-coding leader sequences. Transformation of a target plant with such a DNA construct may lead to a reduction in the amount of lignin synthesized by the plant by the process of cosuppression, in a manner similar to that

discussed, for example, by Napoli et al. (Plant Cell 2:279-290, 1990) and de Carvalho Niebel et al. (Plant Cell 7:347-358, 1995).

The DNA constructs of the present invention further comprise a gene promoter sequence and a gene termination sequence, operably linked to the DNA sequence to be transcribed, which control expression of the gene. The gene promoter sequence is generally positioned at the 5' end of the DNA sequence to be transcribed, and is employed to initiate transcription of the DNA sequence. Gene promoter sequences are generally found in the 5' non-coding region of a gene but they may exist in introns (Luehrsen, K. R., Mol. Gen. Genet. 225:81-93, 1991) or in the coding region, as for example in PAL of tomato (Bloksberg, 1991, Studies on the Biology of Phenylalanine Ammonia Lyase and Plant Pathogen Interaction. Ph.D. Thesis, Univ. of California, Davis, University Microfilms International order number 9217564). When the construct includes an open reading frame in a sense orientation, the gene promoter sequence also initiates translation of the open reading frame. For DNA constructs comprising either an open reading frame in an antisense orientation or a non-coding region, the gene promoter sequence consists only of a transcription initiation site having a RNA polymerase binding site.

A variety of gene promoter sequences which may be usefully employed in the DNA constructs of the present invention are well known in the art. The promoter gene sequence, and also the gene termination sequence, may be endogenous to the target plant host or may be exogenous, provided the promoter is functional in the target host. For example, the promoter and termination sequences may be from other plant species, plant viruses, bacterial plasmids and the like. Preferably, gene promoter and termination sequences are from the inventive sequences themselves.

Factors influencing the choice of promoter include the desired tissue specificity of the construct, and the timing of transcription and translation. For example, constitutive promoters, such as the 35S Cauliflower Mosaic Virus (CaMV 35S) promoter, will affect the activity of the enzyme in all parts of the plant. Use of a tissue specific promoter will result in production of the desired sense or antisense RNA only in the tissue of interest. With DNA constructs employing inducible gene promoter sequences, the rate of RNA polymerase binding and initiation can be modulated by external stimuli, such as light, heat, anaerobic stress, alteration in nutrient conditions

and the like. Temporally regulated promoters can be employed to effect modulation of the rate of RNA polymerase binding and initiation at a specific time during development of a transformed cell. Preferably, the original promoters from the enzyme gene in question, or promoters from a specific tissue-targeted gene in the organism to be transformed, such as eucalyptus or pine are used. Other examples of gene promoters which may be usefully employed in the present invention include, mannopine synthase (mas), octopine synthase (ocs) and those reviewed by Chua et al. (Science, 244:174-181, 1989).

The gene termination sequence, which is located 3' to the DNA sequence to be transcribed, may come from the same gene as the gene promoter sequence or may be from a different gene. Many gene termination sequences known in the art may be usefully employed in the present invention, such as the 3' end of the *Agrobacterium tumefaciens* nopaline synthase gene. However, preferred gene terminator sequences are those from the original enzyme gene or from the target species to be transformed.

The DNA constructs of the present invention may also contain a selection marker that is effective in plant cells, to allow for the detection of transformed cells containing the inventive construct. Such markers, which are well known in the art, typically confer resistance to one or more toxins. One example of such a marker is the NPTII gene whose expression results in resistance to kanamycin or hygromycin, antibiotics which is usually toxic to plant cells at a moderate concentration (Rogers et al. in Methods for Plant Molecular Biology, A. Weissbach and H. Weissbach, eds., Academic Press Inc., San Diego, CA (1988)). Alternatively, the presence of the desired construct in transformed cells can be determined by means of other techniques well known in the art, such as Southern and Western blots.

Techniques for operatively linking the components of the inventive DNA constructs are well known in the art and include the use of synthetic linkers containing one or more restriction endonuclease sites as described, for example, by Maniatis et al., (*Molecular Cloning: A Laboratory Manual*, Cold Spring Harbor Laboratories, Cold Spring Harbor, NY, 1989). The DNA construct of the present invention may be linked to a vector having at least one replication system, for example, *E. coli*, whereby after each manipulation, the resulting construct can be cloned and sequenced and the correctness of the manipulation determined.

The DNA constructs of the present invention may be used to transform a variety of plants, both monocotyledonous (e.g. grasses, corn, grains, oat, wheat and barley), dicotyledonous (e.g. *Arabidopsis*, tobacco, legumes, alfalfa, oaks, eucalyptus, maple), and Gymnosperms (e.g. Scots pine (Aronen, Finnish Forest Res. Papers, vol. 595, 1996), white spruce (Ellis et al., Biotechnology 11:94-92, 1993), larch (Huang et al., In Vitro Cell 27:201-207, 1991)). In a preferred embodiment, the inventive DNA constructs are employed to transform woody plants, herein defined as a tree or shrub whose stem lives for a number of years and increases in diameter each year by the addition of woody tissue. Preferably the target plant is selected from the group consisting of eucalyptus and pine species, most preferably from the group consisting of *Eucalyptus grandis* and *Pinus radiata*. As discussed above, transformation of a plant with a DNA construct including an open reading frame coding for an enzyme encoded by an inventive DNA sequence wherein the open reading frame is orientated in a sense direction will lead to an increase in lignin content of the plant or, in some cases, to a decrease by cosuppression. Transformation of a plant with a DNA construct comprising an open reading frame in an antisense orientation or a non-coding (untranslated) region of a gene will lead to a decrease in the lignin content of the transformed plant.

Techniques for stably incorporating DNA constructs into the genome of target plants are well known in the art and include *Agrobacterium tumefaciens* mediated introduction, electroporation, protoplast fusion, injection into reproductive organs, injection into immature embryos, high velocity projectile introduction and the like. The choice of technique will depend upon the target plant to be transformed. For example, dicotyledonous plants and certain monocots and gymnosperms may be transformed by *Agrobacterium* Ti plasmid technology, as described, for example by Bevan (Nucl. Acid Res. 12:8711-8721, 1984). Targets for the introduction of the DNA constructs of the present invention include tissues, such as leaf tissue, disseminated cells, protoplasts, seeds, embryos, meristematic regions; cotyledons, hypocotyls, and the like. One preferred method for transforming eucalyptus and pine is a biolistic method using pollen (see, for example, Aronen 1996, Finnish Forest Res. Papers vol. 595, 53pp) or easily regenerable embryonic tissues. Other transformation techniques which may be usefully employed in the inventive methods include those taught by Ellis et al. (Plant

Cell Reports, 8:16-20, 1989), Wilson et al. (Plant Cell Reports 7:704-707, 1989) and Tautorus et al. (Theor. Appl. Genet. 78:531-536, 1989).

Once the cells are transformed, cells having the inventive DNA construct incorporated in their genome may be selected by means of a marker, such as the kanamycin resistance marker discussed above. Transgenic cells may then be cultured in an appropriate medium to regenerate whole plants, using techniques well known in the art. In the case of protoplasts, the cell wall is allowed to reform under appropriate osmotic conditions. In the case of seeds or embryos, an appropriate germination or callus initiation medium is employed. For explants, an appropriate regeneration medium is used. Regeneration of plants is well established for many species. For a review of regeneration of forest trees see Dunstan et al., Somatic embryogenesis in woody plants. In: Thorpe, T.A. ed., 1995: in vitro embryogenesis of plants. Vol. 20 in Current Plant Science and Biotechnology in Agriculture, Chapter 12, pp. 471-540. Specific protocols for the regeneration of spruce are discussed by Roberts et al., (Somatic Embryogenesis of Spruce. In: *Synseed. Applications of synthetic seed to crop improvement*. Redenbaugh, K., ed. CRC Press, Chapter 23, pp. 427-449, 1993). The resulting transformed plants may be reproduced sexually or asexually, using methods well known in the art, to give successive generations of transgenic plants.

As discussed above, the production of RNA in target plant cells can be controlled by choice of the promoter sequence, or by selecting the number of functional copies or the site of integration of the DNA sequences incorporated into the genome of the target plant host. A target plant may be transformed with more than one DNA construct of the present invention, thereby modulating the lignin biosynthetic pathway for the activity of more than one enzyme, affecting enzyme activity in more than one tissue or affecting enzyme activity at more than one expression time. Similarly, a DNA construct may be assembled containing more than one open reading frame coding for an enzyme encoded by a DNA sequence of the present invention or more than one non-coding region of a gene coding for such an enzyme. The DNA sequences of the present inventive may also be employed in combination with other known sequences encoding enzymes involved in the lignin biosynthetic pathway. In this manner, it may be possible to add a lignin biosynthetic pathway to a non-woody plant to produce a new woody plant.

The isolated DNA sequences of the present invention may also be employed as probes to isolate DNA sequences encoding enzymes involved in the lignin synthetic pathway from other plant species, using techniques well known to those of skill in the art.

5 The following examples are offered by way of illustration and not by way of limitation.

Example 1

Isolation and Characterization of cDNA Clones from *Eucalyptus grandis*

10 Two *Eucalyptus grandis* cDNA expression libraries (one from a mixture of various tissues from a single tree and one from leaves of a single tree) were constructed and screened as follows.

mRNA was extracted from the plant tissue using the protocol of Chang et al. (Plant Molecular Biology Reporter 11:113-116 (1993)) with minor modifications. Specifically, samples were dissolved in CPC-RNAXB (100 mM Tris-Cl, pH 8.0; 25 mM EDTA; 2.0 M NaCl; 2%CTAB; 2% PVP and 0.05% Spermidine*3 HCl) and extracted with Chloroform:isoamyl alcohol, 24:1. mRNA was precipitated with ethanol and the total RNA prepate was purified using a Poly(A) Quik mRNA Isolation Kit (Stratagene, La Jolla, CA). A cDNA expression library was constructed from the purified mRNA by reverse transcriptase synthesis followed by insertion of the resulting cDNA clones in Lambda ZAP using a ZAP Express cDNA Synthesis Kit (Stratagene), according to the manufacturer's protocol. The resulting cDNAs were packaged using a Gigapack II Packaging Extract (Stratagene) employing 1 µl of sample DNA from the 5 µl ligation mix. Mass excision of the library was done using XL1-Blue MRF' cells and XL0LR cells (Stratagene) with ExAssist helper phage (Stratagene). The excised phagemids were diluted with NZY broth (Gibco BRL, Gaithersburg, MD) and plated out onto LB-kanamycin agar plates containing X-gal and isopropylthio-beta-galactoside (IPTG).

25 Of the colonies plated and picked for DNA miniprep, 99% contained an insert suitable for sequencing. Positive colonies were cultured in NZY broth with kanamycin and cDNA was purified by means of alkaline lysis and polyethylene glycol (PEG) precipitation. Agarose gel at 1% was used to screen sequencing templates for

chromosomal contamination. Dye primer sequences were prepared using a Turbo Catalyst 800 machine (Perkin Elmer/Applied Biosystems, Foster City, CA) according to the manufacturer's protocol.

DNA sequence for positive clones was obtained using an Applied Biosystems Prism 377 sequencer. cDNA clones were sequenced first from both the 5' end and, in some cases, also from the 3' end. For some clones, internal sequence was obtained using subcloned fragments. Subcloning was performed using standard procedures of restriction mapping and subcloning to pBluescript II SK+ vector.

The determined cDNA sequence was compared to known sequences in the EMBL database (release 46, March 1996) using the FASTA algorithm of February 1996 (version 2.0u4) (available on the Internet at the ftp site ftp://ftp.virginia.edu/pub/fasta/). Multiple alignments of redundant sequences were used to build up reliable consensus sequences. Based on similarity to known sequences from other plant species, the isolated DNA sequence (SEQ ID NO: 1) was identified as encoding a CAD enzyme.

In further studies, using the procedure described above, cDNA sequences encoding the following *Eucalyptus grandis* enzymes were isolated: PAL (SEQ ID NO: 16); C4H (SEQ ID NO: 17); C3H (SEQ ID NO: 18); F5H (SEQ ID NO: 19-21); OMT (SEQ ID NO: 22-25); CCR (SEQ ID NO: 26-29); CAD (SEQ ID NO: 30); CGT (SEQ ID NO: 31-33); CBG (SEQ ID NO: 34); PNL (SEQ ID NO: 35, 36); LAC (SEQ ID NO: 37-41); and POX (SEQ ID NO: 42-44).

Example 2

Isolation and Characterization of cDNA Clones from *Pinus radiata*

a) Isolation of cDNA clones by high through-put screening

A *Pinus radiata* cDNA expression library was constructed from xylem and screened as described above in Example 1. DNA sequence for positive clones was obtained using forward and reverse primers on an Applied Biosystems Prism 377 sequencer and the determined sequences were compared to known sequences in the database as described above.

Based on similarity to known sequences from other plant species, the isolated DNA sequences were identified as encoding the enzymes C4H (SEQ ID NO: 2 and 3), C3H (SEQ ID NO: 4), PNL (SEQ ID NO: 5), OMT (SEQ ID NO: 6), CAD (SEQ ID NO: 7), CCR (SEQ ID NO: 8), PAL (SEQ ID NO: 9-11) and 4CL (SEQ ID NO: 12).

5 In further studies, using the procedure described above, additional cDNA clones encoding the following *Pinus radiata* enzymes were isolated: PAL (SEQ ID NO: 45-47); C4H (SEQ ID NO: 48, 49); C3H (SEQ ID NO: 50-52); OMT (SEQ ID NO: 53-55); 4CL (SEQ ID NO: 56, 57); CCR (SEQ ID NO: 58-70); CAD (SEQ ID NO: 71); CGT (SEQ ID NO: 72); CBG (SEQ ID NO: 73-80); PNL (SEQ ID NO: 81); LAC
10 (SEQ ID NO: 82-84); and POX (SEQ ID NO: 85-88).

b) Isolation of cDNA clones by PCR

Two PCR probes, hereinafter referred to as LNB010 and LNB011 (SEQ ID NO: 14 and 15, respectively) were designed based on conserved domains in the following
15 peroxidase sequences previously identified in other species: vanpox, hvupox6, taepox, hvupox1, osapox, ntopox2, ntopox1, lespox, pokpox, luspox, athpox, hrpox, spopox, and tvepox (Genbank accession nos. D11337, M83671, X56011, X58396, X66125, J02979, D11396, X71593, D11102, L07554, M58381, X57564, Z22920, and Z31011, respectively).

20 RNA was isolated from pine xylem and first strand cDNA was synthesized as described above. This cDNA was subjected to PCR using 4 μ M LNB010, 4 μ M LNB011, 1 x Kogen's buffer, 0.1 mg/ml BSA, 200 mM dNTP, 2 mM Mg^{2+} , and 0.1 U/ μ l of Taq polymerase (Gibco BRL). Conditions were 2 cycles of 2 min at 94 °C, 1 min at 55 °C and 1 min at 72 °C; 25 cycles of 1 min at 94 °C, 1 min at 55 °C, and 1 min
25 at 72 °C; and 18 cycles of 1 min at 94 °C, 1 min at 55 °C, and 3 min at 72 °C in a Stratagene Robocycler. The gene was re-amplified in the same manner. A band of about 200 bp was purified from a TAE agarose gel using a Schleicher & Schuell Elu-Quik DNA purification kit and clones into a T-tailed pBluescript vector (Marchuk D. et al., Nucleic Acids Res. 19:1154, 1991). Based on similarity to known sequences, the
30 isolated gene (SEQ ID NO: 13) was identified as encoding pine peroxidase (POX).

Example 3Use of an O-methyltransferase (OMT) Gene to Modify Lignin Biosynthesis5 a) Transformation of tobacco plants with a *Pinus radiata* OMT gene

Sense and anti-sense constructs containing a sequence including the coding region of OMT (SEQ ID NO: 53) from *Pinus radiata* were inserted into *Agrobacterium tumefaciens* LBA4301 (provided as a gift by Dr. C. Kado, University of California, Davis, CA) by direct transformation using published methods (see, An G, Ebert PR, 10 Mitra A, Ha SB: Binary Vectors. In: Gelvin SB, Schilperoort RA (eds) Plant Molecular Biology Manual. Kluwer Academic Publishers, Dordrecht (1988)). The presence and integrity of the transgenic constructs were verified by restriction digestion and DNA sequencing.

Tobacco (*Nicotiana tabacum* cv. Samsun) leaf sections were transformed using 15 the method of Horsch et al. (Science, 227:1229-1231, 1985). Five independent transformed plant lines were established for the sense construct and eight independent transformed plant lines were established for the anti-sense construct for OMT. Transformed plants containing the appropriate lignin gene construct were verified using Southern blot experiments. A "+" in the column labeled "Southern" in Table 1 below 20 indicates that the transformed plant lines were confirmed as independent transformed lines.

b) Expression of *Pinus* OMT in transformed plants

Total RNA was isolated from each independent transformed plant line created 25 with the OMT sense and anti-sense constructs. The RNA samples were analysed in Northern blot experiments to determine the level of expression of the transgene in each transformed line. The data shown in the column labeled "Northern" in Table 1 shows that the transformed plant lines containing the sense and anti-sense constructs for OMT all exhibited high levels of expression, relative to the background on the Northern blots. 30 OMT expression in sense plant line number 2 was not measured because the RNA sample showed signs of degradation. There was no detectable hybridisation to RNA samples from empty vector-transformed control plants.

c) Modulation of OMT enzyme activity in transformed plants

The total activity of OMT enzyme, encoded by the *Pinus* OMT gene and by the endogenous tobacco OMT gene, in transformed tobacco plants was analysed for each transformed plant line created with the OMT sense and anti-sense constructs. Crude protein extracts were prepared from each transformed plant and assayed using the method of Zhang et al. (*Plant Physiol.*, 113:65-74, 1997). The data contained in the column labeled "Enzyme" in Table 1 shows that the transformed plant lines containing the OMT sense construct generally had elevated OMT enzyme activity, with a maximum of 199%, whereas the transformed plant lines containing the OMT anti-sense construct generally had reduced OMT enzyme activity, with a minimum of 35%, relative to empty vector-transformed control plants. OMT enzyme activity was not estimated in sense plant line number 3.

d) Effects of *Pinus* OMT on lignin concentration in transformed plants

The concentration of lignin in the transformed tobacco plants was determined using the well-established procedure of thioglycolic acid extraction (see, Freudenberg et al. in "Constitution and Biosynthesis of Lignin", Springer-Verlag, Berlin, 1968). Briefly, whole tobacco plants, of an average age of 38 days, were frozen in liquid nitrogen and ground to a fine powder in a mortar and pestle. 100 mg of frozen powder from one empty vector-transformed control plant line, the five independent transformed plant lines containing the sense construct for OMT and the eight independent transformed plant lines containing the anti-sense construct for OMT were extracted individually with methanol, followed by 10% thioglycolic acid and finally dissolved in 1 M NaOH. The final extracts were assayed for absorbance at 280 nm. The data shown in the column labelled "TGA" in Table 1 shows that the transformed plant lines containing the sense and the anti-sense OMT gene constructs all exhibited significantly decreased levels of lignin, relative to the empty vector-transformed control plant lines.

Table 1

	plant line	transgene orientation	Southern	Northern	Enzyme	TGA	
5							
	1	control	na	+	blank	100	104
	1	OMT	sense	+	2.9E+6	86	55
	2	OMT	sense	+	na	162	58
	3	OMT	sense	+	4.1E+6	na	63
10	4	OMT	sense	+	2.3E+6	142	66
	5	OMT	sense	+	3.6E+5	199	75
	1	OMT	anti-sense	+	1.6E+4	189	66
	2	OMT	anti-sense	+	5.7E+3	35	70
	3	OMT	anti-sense	+	8.0E+3	105	73
15	4	OMT	anti-sense	+	1.4E+4	109	74
	5	OMT	anti-sense	+	2.5E+4	87	78
	6	OMT	anti-sense	+	2.5E+4	58	84
	7	OMT	anti-sense	+	2.5E+4	97	92
	8	OMT	anti-sense	+	1.1E+4	151	94
20							

These data clearly indicate that lignin concentration, as measured by the TGA assay, can be directly manipulated by either sense or anti-sense expression of a lignin biosynthetic gene such as OMT.

Example 4Use of a 4-Coumarate:CoA ligase (4CL) Gene to Modify Lignin Biosynthesisa) Transformation of tobacco plants with a *Pinus radiata* 4CL gene

Sense and anti-sense constructs containing a sequence including the coding region of 4CL (SEQ ID NO: 56) from *Pinus radiata* were inserted into *Agrobacterium tumefaciens* LBA4301 by direct transformation as described above. The presence and integrity of the transgenic constructs were verified by restriction digestion and DNA sequencing.

Tobacco (*Nicotiana tabacum* cv. Samsun) leaf sections were transformed as described above. Five independent transformed plant lines were established for the sense construct and eight independent transformed plant lines were established for the anti-sense construct for 4CL. Transformed plants containing the appropriate lignin gene construct were verified using Southern blot experiments. A "+" in the column

labeled "Southern" in Table 2 indicates that the transformed plant lines listed were confirmed as independent transformed lines.

b) Expression of *Pinus* 4CL in transformed plants

5 Total RNA was isolated from each independent transformed plant line created with the 4CL sense and anti-sense constructs. The RNA samples were analysed in Northern blot experiments to determine the level of expression of the transgene in each transformed line. The data shown in the column labelled "Northern" in Table 2 below shows that the transformed plant lines containing the sense and anti-sense constructs for
10 4CL all exhibit high levels of expression, relative to the background on the Northern blots. 4CL expression in anti-sense plant line number 1 was not measured because the RNA was not available at the time of the experiment. There was no detectable hybridisation to RNA samples from empty vector-transformed control plants.

15 c) Modulation of 4CL enzyme activity in transformed plants

 The total activity of 4CL enzyme, encoded by the *Pinus* 4CL gene and by the endogenous tobacco 4CL gene, in transformed tobacco plants was analysed for each transformed plant line created with the 4CL sense and anti-sense constructs. Crude protein extracts were prepared from each transformed plant and assayed using the
20 method of Zhang et al. (Plant Physiol., 113:65-74, 1997). The data contained in the column labeled "Enzyme" in Table 2 shows that the transformed plant lines containing the 4CL sense construct had elevated 4CL enzyme activity, with a maximum of 258%, and the transformed plant lines containing the 4CL anti-sense construct had reduced 4CL enzyme activity, with a minimum of 59%, relative to empty vector-transformed
25 control plants.

d) Effects of *Pinus* 4CL on lignin concentration in transformed plants

 The concentration of lignin in samples of transformed plant material was determined as described in Example 3. The data shown in the column labelled "TGA"
30 in Table 2 shows that the transformed plant lines containing the sense and the anti-sense 4CL gene constructs all exhibited significantly decreased levels of lignin, relative to the empty vector-transformed control plant lines. These data clearly indicate that

lignin concentration, as measured by the TGA assay, can be directly manipulated by either sense or anti-sense expression of a lignin biosynthetic gene such as 4CL.

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Table 2

	plant line	transgene	orientation	Southern	Northern	Enzyme	TGA
	1	control	na	+	blank	100	92
10	2	control	na	+	blank	100	104
	1	4CL	sense	+	2.3E+4	169	64
	2	4CL	sense	+	4.5E+4	258	73
	3	4CL	sense	+	3.1E+4	174	77
	4	4CL	sense	+	1.7E+4	164	80
15	5	4CL	sense	+	1.6E+4	184	92
	1	4CL	anti-sense	+	na	59	75
	2	4CL	anti-sense	+	1.0E+4	70	75
	3	4CL	anti-sense	+	9.6E+3	81	80
	4	4CL	anti-sense	+	1.2E+4	90	83
20	5	4CL	anti-sense	+	4.7E+3	101	88
	6	4CL	anti-sense	+	3.9E+3	116	89
	7	4CL	anti-sense	+	1.8E+3	125	94
	8	4CL	anti-sense	+	1.7E+4	106	97

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Example 5Transformation of Tobacco using the Inventive Lignin Biosynthetic Genes

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Sense and anti-sense constructs containing sequences including the coding regions of C3H (SEQ ID NO: 18), F5H (SEQ ID NO: 19), CCR (SEQ ID NO: 25) and CGT (SEQ ID NO: 31) from *Eucalyptus grandis*, and PAL (SEQ ID NO: 45 and 47), C4H (SEQ ID NO: 48 and 49), PNL (SEQ ID NO: 81) and LAC (SEQ ID NO: 83) from *Pinus radiata* were inserted into *Agrobacterium tumefaciens* LBA4301 by direct transformation as described above. The presence and integrity of the transgenic constructs were verified by restriction digestion and DNA sequencing.

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Tobacco (*Nicotiana tabacum* cv. Samsun) leaf sections were transformed as described in Example 3. Up to twelve independent transformed plant lines were established for each sense construct and each anti-sense construct listed in the preceding paragraph. Transformed plants containing the appropriate lignin gene

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construct were verified using Southern blot experiments. All of the transformed plant lines analysed were confirmed as independent transformed lines.

Example 6

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Manipulation of Lignin Content in Transformed Plants

a) Determination of transgene expression by Northern blot experiments

Total RNA was isolated from each independent transformed plant line described in Example 5. The RNA samples were analysed in Northern blot experiments to determine the level of expression of the transgene in each transformed line. The column labelled "Northern" in Table 3 shows the level of transgene expression for all plant lines assayed, relative to the background on the Northern blots. There was no detectable hybridisation to RNA samples from empty vector-transformed control plants.

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b) Determination of lignin concentration in transformed plants

The concentration of lignin in empty vector-transformed control plant lines and in up to twelve independent transformed lines for each sense construct and each anti-sense construct described in Example 5 was determined as described in Example 3. The column labelled "TGA" in Table 3 shows the thioglycolic acid extractable lignins for all plant lines assayed, expressed as the average percentage of TGA extractable lignins in transformed plants versus control plants. The range of variation is shown in parentheses.

20

Table 3

	transgene	orientation	no. of lines	Northern	TGA
5	control	na	3	blank	100 (92-104)
	C3H	sense	5	3.7E+4	74 (67-85)
	F5H	sense	10	5.8E+4	70 (63-79)
	F5H	anti-sense	9	5.8E+4	73 (35-93)
10	CCR	sense	1	na	74
	CCR	anti-sense	2	na	74 (62-86)
	PAL	sense	5	1.9E+5	77 (71-86)
	PAL	anti-sense	4	1.5E+4	62 (37-77)
	C4H	anti-sense	10	5.8E+4	86 (52-113)
15	PNL	anti-sense	6	1.2E+4	88 (70-114)
	LAC	sense	5	1.7E+5	na
	LAC	anti-sense	12	1.7E+5	88 (73-114)

Transformed plant lines containing the sense and the anti-sense lignin biosynthetic gene constructs all exhibited significantly decreased levels of lignin, relative to the empty vector-transformed control plant lines. The most dramatic effects on lignin concentration were seen in the F5H anti-sense plants with as little as 35% of the amount of lignin in control plants, and in the PAL anti-sense plants with as little as 37% of the amount of lignin in control plants. These data clearly indicate that lignin concentration, as measured by the TGA assay, can be directly manipulated by conventional anti-sense methodology and also by sense over-expression using the inventive lignin biosynthetic genes.

Example 7Modulation of Lignin Enzyme Activity in Transformed Plants

The activities and substrate specificities of selected lignin biosynthetic enzymes were assayed in crude extracts from transformed tobacco plants containing sense and anti-sense constructs for PAL (SEQ ID NO: 45), PNL (SEQ ID NO: 81) and LAC (SEQ ID NO: 83) from *Pinus radiata*, and CGT (SEQ ID NO: 31) from *Eucalyptus grandis*.

Enzyme assays were performed using published methods for PAL (Southerton, S.G. and Deverall, B.J., Plant Path. 39:223-230, 1990), CGT (Vellekoop, P. et al., FEBS, 330:36-40, 1993), PNL (Espín, C.J. et al., Phytochemistry, 44:17-22, 1997) and

LAC (Bao, W. et al., Science, 260:672-674, 1993). The data shown in the column labelled "Enzyme" in Table 4 shows the average enzyme activity from replicate measures for all plant lines assayed, expressed as a percent of enzyme activity in empty vector-transformed control plants. The range of variation is shown in parentheses.

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Table 4

	<u>transgene</u>	<u>orientation</u>	<u>no. of lines</u>	<u>Enzyme</u>
10	control	na	3	100
	PAL	sense	5	87 (60-124)
	PAL	anti-sense	3	53 (38-80)
	CGT	anti-sense	1	89
	PNL	anti-sense	6	144 (41-279)
15	LAC	sense	5	78 (16-240)
	LAC	anti-sense	11	64 (14-106)

All of the transformed plant lines, except the PNL anti-sense transformed plant lines, showed average lignin enzyme activities which were significantly lower than the activities observed in empty vector-transformed control plants. The most dramatic effects on lignin enzyme activities were seen in the PAL anti-sense transformed plant lines in which all of the lines showed reduced PAL activity and in the LAC anti-sense transformed plant lines which showed as little as 14% of the LAC activity in empty vector-transformed control plant lines.

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Example 8Functional Identification of Lignin Biosynthetic Genes

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Sense constructs containing sequences including the coding regions for PAL (SEQ ID NO: 47), OMT (SEQ ID NO: 53), 4CL (SEQ ID NO: 56 and 57) and POX (SEQ ID NO: 86) from *Pinus radiata*, and OMT (SEQ ID NO: 23 and 24), CCR (SEQ ID NO: 26-28), CGT (SEQ ID NO: 31 and 33) and POX (SEQ ID NO: 42 and 44) from *Eucalyptus grandis* were inserted into the commercially available protein expression vector, pProEX-1 (Gibco BRL). The resultant constructs were transformed into *E. coli* XL1-Blue (Stratagene), which were then induced to produce recombinant protein by the addition of IPTG. Purified proteins were produced for the *Pinus* OMT and 4CL constructs and the *Eucalyptus* OMT and POX constructs using Ni column

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chromatography (Janknecht, R. et al., Proc. Natl. Acad. Sci., 88:8972-8976, 1991). Enzyme assays for each of the purified proteins conclusively demonstrated the expected substrate specificity and enzymatic activity for the genes tested.

The data for two representative enzyme assay experiments, demonstrating the verification of the enzymatic activity of a *Pinus radiata* 4CL gene (SEQ ID NO: 56) and a *Pinus radiata* OMT gene (SEQ ID NO: 53), are shown in Table 5. For the 4CL enzyme, one unit equals the quantity of protein required to convert the substrate into product at the rate of 0.1 absorbance units per minute. For the OMT enzyme, one unit equals the quantity of protein required to convert 1 pmole of substrate to product per minute.

Table 5

	purification	total ml	total mg	total units	% yield	fold
<u>transgene</u>	<u>step</u>	<u>extract</u>	<u>protein</u>	<u>activity</u>	<u>activity</u>	<u>purification</u>
4CL	crude	10 ml	51 mg	4200	100	1
	Ni column	4 ml	0.84 mg	3680	88	53
OMT	crude	10 ml	74 mg	4600	100	1
	Ni column	4 ml	1.2 mg	4487	98	60

The data shown in Table 5 indicate that both the purified 4CL enzyme and the purified OMT enzyme show high activity in enzyme assays, confirming the identification of the 4CL and OMT genes described in this application. Crude protein preparations from *E. coli* transformed with empty vector show no activity in either the 4CL or the OMT enzyme assay.

Although the present invention has been described in some detail by way of illustration and example for purposes of clarity of understanding, changes and modifications can be carried out without departing from the scope of the invention which is intended to be limited only by the scope of the appended claims.

SEQUENCE LISTING

(1) GENERAL INFORMATION

- (i) APPLICANT: Genesis Research and Development Corp. Ltd.
- (ii) TITLE OF THE INVENTION: MATERIALS AND METHODS FOR
THE MODIFICATION OF PLANT LIGNIN CONTENT
- (iii) NUMBER OF SEQUENCES: 88
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 - (F) ZIP:
- (v) COMPUTER READABLE FORM:
 - (A) MEDIUM TYPE: Diskette
 - (B) COMPUTER: IBM Compatible
 - (C) OPERATING SYSTEM: DOS
 - (D) SOFTWARE: Wordperfect 5.1
- (vi) CURRENT APPLICATION DATA:
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(2) INFORMATION FOR SEQ ID NO:1:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 535 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:1:

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CTTCGCGCTA CCGCATACTC CACCACCGCG TGCAGAAGAT GAGCTCGGAG GGTGGGAAGG
60
AGGATTGCCT CGGTTGGGCT GCCCGGGACC CTTCTGGGT CCTCTCCCN TACAAATTCA
120
CCCGCAGGCC GTGGGAAGCG AAGACGTCTC GATTAAGATC ACGCACTGTG GAGTGTGCTA
180
CGCAGATGTG GCTTGGACTA GGAATGTGCA GGGACACTCC AAGTATCCTC TGGTGCCGGG
240

```

GCACGAGATA GTTGAATTG TGAAACAGGT TGGCTCCAGT GTCCAACGCT TCAAAGTTGG
 300
 CGATCATGTG GGGGTGGGAA CTTATGTCAA TTCATGCAGA GAGTGCGAGT ATTGCAATGA
 360
 CAGGCTAGAA GTCCAATGTG AAAAGTCGGT TATGACTTTT GATGGAATTG ATGCAGATGG
 420
 TACAGTGACA AAGGGAGGAT ATTCTAGTCA CATTGTCGTC CATGAAAGGT ATTGCGTCAG
 480
 GATTCCAGAA AACTACCCGA TGGATCTAGC AGCGCATTGC TCTGTGCTGG ATCAC
 535

(2) INFORMATION FOR SEQ ID NO:2:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 671 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:2:

GCGCCTGCAG GTCGACACTA GTGGATCCAA AGAATTCGGC ACGAGGTTGC AGGTCGGGGA
 60
 TGATTTGAAT CACAGAAACC TCAGCGATTT TGCCAAGAAA TATGGCAAAA TCTTTCTGCT
 120
 CAAGATGGGC CAGAGGAATC TTGTGGTAGT TTCATCTCCC GATCTCGCCA AGGAGGTCCT
 180
 GCACACCCAG GCGTCGAGT TTGGGTCTCG AACCCGGAAC GTGGTGTTCTG ATATCTTCAC
 240
 GGGCAAGGGG CAGGACATGG TGTTCACCGT CTATGGAGAT CACTGGAGAA AGATGCGCAG
 300
 GATCATGACT GTGCCTTTCT TTACGAATAA AGTTGTCCAG CACTACAGAT TCGCGTGGGA
 360
 AGACGAGATC AGCCGCGTGG TCGCGGATGT GAAATCCCGC GCCGAGTCTT CCACCTCGGG
 420
 CATTGTCATC CGTAGCGCCT CCAGCTCATG ATGTATAATA TTATGTATAG GATGATGTTC
 480
 GACAGGAGAT TCGAATCCGA GGACGACCCG CTTTTCTCA AGCTCAAGGC CCTCAACGGA
 540
 GAGCGAAGTC GATTGGCCCA GAGCTTTGAG TACAATTATG GGGATTTTAT TCCCAGTCTT
 600
 AGGCCCTTCC TCAGAGGTTA TCACAGAATC TGCAATGAGA TTAAAGAGAA ACGGCTCTCT
 660
 CTTTTCAAGG A
 671

(2) INFORMATION FOR SEQ ID NO:3:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 940 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:3:

CTTCAGGACA AGGGAGAGAT CAATGAGGAT AATGTTTTGT ACATCGTTGA GAACATCAAC
 60
 GTTGCAAGCA TTGAGACAAC GCTGTGGTCG ATGGAATGGG GAATAGCGGA GCTGGTGAAC
 120
 CACCAGGACA TTCAGAGCAA GGTGCGCGCA GAGCTGGACG CTGTTCTTGG ACCAGGCGTG
 180
 CAGATAACGG AACCAGACAC GACAAGGTTG CCCTACCTTC AGGCGGTTGT GAAGGAAACC
 240

CTTCTGTCTCC GCATGGCGAT CCGGTTGCTC GTCCCCCACA TGAATCTCCA CGACGCCAAG
 300
 CTCGGGGGGCT ACGATATTCC GGCAGAGAGC AAGATCCTGG TGAACGCCTG GTGGTTGGCC
 360
 AACAAACCCCG CCAACTGGAA GAACCCCGAG GAGTTCCGCC CCGAGCGGTT CTTCGAGGAG
 420
 GAGAAGCACA CCGAAGCCAA TGGCAACGAC TTCAAATTCC TGNCTTCCG TGTGGGGAGG
 480
 AGGAGCTGCC CGGGAATCAT TCTGGCGCTG CTCTCCTCGC ACTCTCCATC GGAAGACTTG
 540
 TTCAGAACTT CCACCTTCTG CCGCCGCCCG GGCAGAGCAA AGTGGATGTC ACTGAGAAGG
 600
 GCGGGCAATT CAGCCTTCAC ATTCTCAACC ATTCTCTCAT CGTCGCCAAG CCCATAGCTT
 660
 CTGCTTAATC CCAACTTGTC AGTGACTGGT ATATAAATGC GGCACCTGA ACAAAAAACA
 720
 CTCCATCTAT CATGACTGTG TGTGCGTGTC CACTGTCGAG TCTACTAAGA GCTCATAGCA
 780
 CTTCAAAAAGT TTGCTAGGAT TTCAATAACA GACACCGTCA ATTATGTCAT GTTTCAATAA
 840
 AAGTTTGCAT AAATTAAATG ATATTTCAAT ATACTATTTT GACTCTCCAC CAATTGGGGA
 900
 ATTTTACTGC TAAAAAAAAA AAAAAAAAAA AAAAAAAAAA
 940

(2) INFORMATION FOR SEQ ID NO:4:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 949 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:4:

NNGCTCNACC GACGGTGGAC GGTCCGCTAC TCAGTAACTG AGTGGGATCC CCCGGGCTGA
 60
 CAGGCAATTC GATTAGCTC ACTCATTAGG CACCCAGGC TTTACACTTT ATGCTTCCGG
 120
 CTCGTATGTT GTGTGGAATT GTGAGCGGAT AACAAATTCA CACAGGAAAC AGCTATGACC
 180
 ATGATTACGC CAAGCGCGCA ATTAACCCTC ACTAAAGGGA ACAAAGCTG GAGCTCCACC
 240
 GCGGTGGCGG CCGCTCTAGA ACTAGTGGAT CCAAAGAATT CGGCACGAGA CCCAGTGACC
 300
 TTCAGGCCTG AGAGATTTCT TGAGGAAGAT GTTGATATTA AGGGCCATGA TTACAGGCTA
 360
 CTGCCATTGG TGCAGGGCGC AGGATCTGCC CTGGTGACA ATTGGGTATT AATTTAGTTC
 420
 AGTCTATGTT GGGACACCTG CTTCAATCATT TCGTATGGGC ACCTCCTGAG GGAATGAAGG
 480
 CAGAAGACAT AGATCTCACA GAGAATCCAG GGCTTGTTAC TTTCATGGCC AAGCCTGTGC
 540
 AGGCCATTGC TATTCCTCGA TTGCCTGATC ATCTCTACAA GCGACAGCCA CTCATTGAT
 600
 CAATTGATCT GATAGTAAGT TTGAATTTTG TTTTGATACA AAACGAAATA ACGTGCAGTT
 660
 TCTCCTTTTC CATAGTCAAC ATGCAGCTTT CTTTCTCTGA AGCGCATGCA GCTTTCTTTC
 720
 TCTGAAGCCC AACTTCTAGC AAGCAATAAC TGTATATTTT AGAACAAATA CCTATTCCTC
 780
 AAATTGAGWA TTTCTCTGTA GGGGNNGNTA ATTGTGCAAT TTGCAAGNAA TAGTAAAGTT
 840
 TANTTTAGGG NATTTTAATA GTCCTANGTA ANANGNGGNA ATGNTAGNGG GCATTNAGAA
 900

ANCCCTAATA GNTGTTGGNG GNNGNTAGGN TTTTNNACCA AAAAAAAAAA
949

(2) INFORMATION FOR SEQ ID NO:5:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 959 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:5:

GAATTCGGCA CGAGAAAGCC CTAGAATTTT TTCAGCATGC TATCACAGCC CCAGCGACAA
60
CTTTAACTGC AATAACTGTG GAAGCGTACA AAAAGTTTGT CCTAGTTTCT CTCATTGAGA
120
CTGGTCAGGT TCCAGCATTT CCAAATACA CACCTGCTGT TGTCCAAAGA AATTTGAAAT
180
CTTGCACTCA GCCCTACATT GATTTAGCAA ACAACTACAG TAGTGGGAAA ATTTCTGTAT
240
TGGAAGCTTG TGTCAACACG AACACAGAGA AGTTCAAGAA TGATAGTAAT TTGGGGTTAG
300
TCAAGCAAGT TTTGTCATCT CTTTATAAAC GGAATATTCA GAGATTGACA CAGACATATC
360
TGACCCCTCTC TCTTCAAGAC ATAGCAAGTA CGGTACAGTT GGAGACTGCT AAGCAGGCTG
420
AACTCCATGT TCTGCAGATG ATTCAAGATG GTGAGATTTT TGCAACCATA AATCAGAAAG
480
ATGGGATGGT GAGCTTCAAT GAGGATCCTG AACAGTACAA AACATGTCAG ATGACTGAAT
540
ATATAGATAC TGCAATTTCGG AGAATCATGG CACTATCAAA GAAGCTCACC ACAGTAGATG
600
AGCAGATTTT GTGTGATCAT TCCTACCTGA GTAAGGTGGG GAGAGAGCGT TCAAGATTTG
660
ACATAGATGA TTTTGATACT GTTCCCCAGA AGTTCANAAA TATGTAACAA ATGATGTAAA
720
TCATCTTCAA GACTCGCTTA TATTCATTAC TTTCTATGTG AATTGATAGT CTGTTAACAA
780
TAGTACTGTG GCTGAGTCCA GAAAGGATCT CTCGGTATTA TCACTTGACA TGCCATCAAA
840
AAAATCTCAA ATTTCTCGAT GTCTAGTCTT GATTTTGATT ATGAATGCCA CTTTGTAGTTG
900
TGACATTTGA GCACCTCGAG TGAAGTACAA AGTTGCATGT TAAAAAAAAA AAAAAAAAAA
959

(2) INFORMATION FOR SEQ ID NO:6:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 1026 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:6:

GAATTCGGCA CGAGCTTTGA GGCAACCTAC ATTCATTGAA TCCCAGGATT TCTTCTTGTC
60
CAAACAGGTT TAAGGAAATG GCAGGCACAA GTGTTGCTGC AGCAGAGGTG AAGGCTCAGA
120
CAACCCAAGC AGAGGAGCCG GTTAAGGTTG TCCGCCATCA AGAAGTGGGA CACAAAAGTC
180
TTTTGCAGAG CGATGCCCTC TATCAGTATA TATTGAAAC GAGCGTGTAC CCTCGTGAGC
240

CCGAGCCAAT GAAGGAGCTC CGCGAAGTGA CTGCCAAGCA TCCCTGGAAC CTCATGACTA
 300
 CTTCTGCCGA TGAGGGTCAA TTTCTGGGCC TCCTGCTGAA GCTCATTAAC GCCAAGAACA
 360
 CCATGGAGAT TGGGGTGTAC ACTGGTTACT CGCTTCTCAG CACAGCCCTT GCATTGCCCC
 420
 ATGATGGAAA GATTCTAGCC ATGGACATCA ACAGAGAGAA CTATGATATC GGATTGCCTA
 480
 TTATTGAGAA AGCAGGAGTT GCCCACAAGA TTGACTTCAG AGAGGGCCCT GCTCTGCCAG
 540
 TTCTGGACGA ACTGCTTAAG AATGAGGACA TGCATGGATC GTTCGATTTT GTGTTTCGTG
 600
 ATGCCGACAA AGACAACTAT CTAACTACC ACAAGCGTCT GATCGATCTG GTGAAGGTTG
 660
 GAGGTCTGAT TGCATATGAC AACACCCTGT GGAACGGATC TGTGGTGGCT CCACCCGATG
 720
 CTCCCCTGAG GAAATATGTG AGATATTACA GAGATTTCTG GATGGAGCTA AACAAGGCC
 780
 TTGCTGTCGA TCCCCGCATT GAGATCAGCC AAATCCCACT CGGTGACGGC GTCACCCTTT
 840
 GCAGGCGTGT CTATTGAAAA CAATCCTTGT TTCTGCTCGT CTATTGCAAG CATAAAGGCT
 900
 CTCTGATTAT AAGGAGAACG CTATAATATA TGGGGTTGAA GCCATTTGTT TTGTTTAGTG
 960
 TATTGATAAT AAAGTAGTAC AGCATATGCA AAGTTTGTAT CAAAAAAAAA AAAAAAAAAA
 1020
 AAAAAA
 1026

(2) INFORMATION FOR SEQ ID NO:7:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 1454 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:7:

GAATTCGGCA CGAGGCCAAC TGCAAGCAAT ACAGTACAAG AGCCAGACGA TCGAATCCTG
 60
 TGAAGTGGTT CTGAAGTGAT GGGAAAGCTT GAATCTGAAA AACTGTGTTAC AGGATATGCA
 120
 GCTCGGGACT CCAGTGGCCA CTTGTCCCCT TACACTTACA ATCTCAGAAA GAAAGGACCT
 180
 GAGGATGTAA TTGTAAAGGT CATTTACTGC GGAATCTGCC ACTCTGATTT AGTTCAAATG
 240
 CGTAATGAAA TGGACATGTC TCATTACCCA ATGGTCCCTG GGCATGAAGT GGTGGGGATT
 300
 GTAACAGAGA TTGGCAGCGA GGTGAAGAAA TTCAAAGTGG GAGAGCATGT AGGGGTTGGT
 360
 TGCATTGTTG GGTCCGTGTC CAGTTGCGGT AATTGCAATC AGAGCATGGA ACAATACTGC
 420
 AGCAAGAGGA TTTGGACCTA CAATGATGTG AACCATGACG GCACACCTAC TCAGGGCGGA
 480
 TTTGCAAGCA GTATGGTGGT TGATCAGATG TWTGTGGTTC GAATCCCGGA GAATCTTCCT
 540
 CTGGAACAAG CGGCCCCCTCT GTTATGTGCA GGGGTTACAG TTTTCAGCCC AATGAAGCAT
 600
 TTCGCCATGA CAGAGCCCGG GAAGAAATGT GGGATTTTGG GTTAGGAGG CGTGGGGCAG
 660
 ATGGGTGTCA AGATTGCCAA AGCCTTTGGA CTCCACGTGA CGGTTATCAG TTCGTCTGAT
 720
 AAAAAAGAAAG AAGAAGCCAT GGAAGTCCTC GSCGCCGATG CTTATCTTGT TAGCAAGGAT
 780

ACTGAAAAGA TGATGGAAGC AGCAGAGAGC CTAGATTACA TAATGGACAC CATTCCAGTT
 840
 GCTCATCCTC TGGAAACCATA TCTTGCCCTT CTGAAGACAA ATGGAAAGCT AGTGATGCTG
 900
 GGCGTTGTTC CAGAGTCGTT GCACTTCGTG ACTCCTCTCT TAATACTTGG GAGAAGGAGC
 960
 ATAGCTGGAA GTTTCATTGG CAGCATGGAG GAAACACAGG AAACCTCTAGA TTTCTGTGCA
 1020
 GAGAAGAAGG TATCATCGAT GATTGAGGTT GTGGGCCTGG ACTACATCAA CACGGCCATG
 1080
 GAAAGGTTGG AGAAGAACGA TGTCCGTTAC AGATTTGTGG TGGATGTTGC TAGAAGCAAG
 1140
 TTGGATAATT AGTCTGCAAT CAATCAATCA GATCAATGCC TGCATGCAAG ATGAATAGAT
 1200
 CTGGACTAGT AGCTTAACAT GAAAGGGAAA TTAAATTTTT ATTTAGGAAC TCGATACTGG
 1260
 TTTTGTGTTAC TTTAGTTTAG CTTTTGTGAG GTTGAAACAA TTCAGATGTT TTTTAACTT
 1320
 GTATATGTAA AGATCAATTT CTCGTGACAG TAAATAATAA TCCAATGTCT TCTGCCAAAT
 1380
 TAATATATGT ATTCGTATTT TTATATGAAA AAAAAAAAAA AAAA
 1454AAAAAAAA AAAAAAAAAA 1440 AAAAAAAAAA AAAA
 1454

(2) INFORMATION FOR SEQ ID NO:8:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 740 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:8:

GAATTCGGCA CGAGACCATT TCCAGCTAAT ATTGGCATAG CAATTGGTCA TTCTATCTTT
 60
 GTCAAAGGAG ATCAAACAAA TTTTGAAATT GGACCTAATG GTGTGGAGGC TAGTCAGCTA
 120
 TACCCAGATG TGAAATATAC CACTGTCGAT GAGTACCTCA GCAAATTTGT GTGAAGTATG
 180
 CGAGATTCTC TTCCACATGC TTCAGAGATA CATAACAGTT TCAATCAATG TTTGTCTTAG
 240
 GCATTTGCCA AATTGTGGGT TATAATCCTT CGTAGGTGTT TGGCAGAACA GAACCTCCTG
 300
 TTTAGTATAG TATGACGAGC TAGGCACTGC AGATCCTTCA CACTTTTCTC TTCCATAAGA
 360
 AACAAATACT CACCTGTGGT TTGTTTTCTT TCTTTCTGGA ACTTTGGTAT GGCAATAATG
 420
 TCTTTGGAAA CCGCTTAGTG TGGAAATGCTA AGTACTAGTG TCCAGAGTTC TAAGGGAGTT
 480
 CCAAAATCAT GGCTGATGTG AACTGGTTGT TCCAGAGGGT GTTTACAACC AACAGTTGTT
 540
 CAGTGAATAA TTTTGTTAGA GTGTTTAGAT CCATCTTTAC AAGGCTATTG AGTAAGGTTG
 600
 GTGTTAGTGA ACGGAATGAT GTCAAATCTT GATGGGCTGA CTGACTCTCT TGTGATGTCA
 660
 AATCTTGATG GATTGTGTCT TTTTCAATGG TAAAAAAAA AAAAAAAAAA AAAAAAAAAA
 740 720 AAAAAAAAAA AAAAAAAAAA
 740

(2) INFORMATION FOR SEQ ID NO:9:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 624 base pairs
- (B) TYPE: nucleic acid

(C) STRANDEDNESS: single
(D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:9:

```

GAATTCCTGC AGCCCGGGGG ATCCACTAGT TCTAGAGCGG CCGCCACCGC GGTGGAGCTC
60
GCGCGCCTGC AGGTCGACAC TAGTGGATCC AAAGAATTCG GCACGAGGCC CGACGGCCAC
120
TTGTTGGACG CCATGGAAGC TCTCCGAAA GCCGGGATTC TGGAACCGTT TAAACTGCAG
180
CCCAAGGAAG GACTGGCTCT CGTCAACGGC ACAGCGGTGG GATCCGCCGT GGCCGCGTCC
240
GTCTGTGTTG ACGCCAACGT GCTGGGCGTG CTGGCTGAGA TTCTGTCTGC GCTCTTCTGC
300
GAGGTGATGC AAGGGAAACC GGAGTTCGTA GATCCGTAA CCCACCAGTT GAAGCACCAC
360
CCAGGGCAGA TCGAAGCCGC GGCCGTCATG GAGTTCCTCC TCGACGGTAG CGACTACGTG
420
AAAGAAGCAG CGCGGCTTCA CGAGAAAGAC CCGTTGAGCA AACCGAAACA AGACCGCTAC
480
GCTCTGCGAA CATCGCCACA GTGGTTGGGG CCTCCGATCG AAGTCATCCG CGCTGCTACT
540
CACTCCATCG AGCGGGAGAT CAATTCCGTC AACGACAATC CGTTAATCGA TGTCTCCAGG
600
GACATGGCTG TCCACGGCGG CAAC
624

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(2) INFORMATION FOR SEQ ID NO:10:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 278 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: single
(D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:10:

```

GAATTCCTGC AGCCCGGGGG ATCCACTAGT TCTAGAGCGG CCGCCACCGC GGTGGAGCTC
60
CAGTACCTGG CCAACCCCGT CACGACTCAC GTCCAGAGCG CCGAACAACA CAACCAGGAT
120
GTCAATTCCC TCGGCTTGAT CTCCGCCAGA AAGACTGCCG AGGCCGTTGA GATTTTAAAG
180
CTGATGTTG CTACATATCT GGTGGCCTTA TGCCAGGCGA TCGATCTCCG GCACCTGGAA
240
GAAAACATGC GATCCGTTGT GAAGCACGTA GTCTTGCA
278

```

(2) INFORMATION FOR SEQ ID NO:11:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 765 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: single
(D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:11:

```

GAGCTCCTGC AAGTCATCGA TCATCAGCCC GTTTTCTCGT ACATCGACGA TCCCACAAAT
60
CCATCATACG CGCTTATGCT CCAACTCAGA GAAGTGCTCG TAGATGAGGC TCTCAAATCA
120

```

TCTTGCCCAG ACGGGAATGA CGAATCCGAT CACAATTTGC AGCCCGCTGA GAGCGCTGGA
 180
 GCTGCTGGAA TATTACCCAA TTGGGTGTTT AGCAGGATCC CCATATTTCA AGAGGAGTTG
 240
 AAGGCCCCGT TAGAGGAAGA GGTTCGGAAG GCGAGGGAAC GATTGATAA TGGGGACTTC
 300
 CCAATTGCAA ACAGAATAAA CAAGTGCAGG ACATATCCCA TTTACAGATT CGTGAGATCA
 360
 GAGTTGGGAA CCGATTGCT AACAGGGCCC AAGTGGAGAA GCCCCGGCGA AGATATAGAA
 420
 AAGGTATTTG AGGGCATTG CCAAGGGAAA ATTGGAAACG TGATCCTCAA ATGTCTGGAC
 480
 GCTTGGGGTG GGTGCGCTGG ACCATTCACT CCACGTGCAT ATCCTGCGTC TCCTGCAGCG
 540
 TTCAATGCCT CATATTGGGC ATGGTTTGAT AGCACCAAAT CACCCTCTGC AACGAGCGGC
 600
 AGAGGTTTCT GGAGCGCCCA ACAACAACAA GTTCTTTGAT TTAAGTACT CTTAAGCATT
 660
 CCTAACAGC TTGTTCTTCG CAATAACGAA TCTTTCATCT TCGTTACTTT GTAAAAGATG
 720
 GGGTTCCAAC AAAATAGAAG AAATATTTTC GATCCAAAAA AAAAA
 765

(2) INFORMATION FOR SEQ ID NO:12:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 453 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:12:

TGATTATGCG GATCCTTGGG CAGGGATACG GCATGACAGA AGCAGGCCCCG GTGCTGGCAA
 60
 TGAACCTAGC CTTCGCAAAG AATCCTTTCC CCGCCAAATC TGGCTCCTGC GGAACAGTCG
 120
 TCCGGAACGC TCAAATAAAG ATCCTCGATT ACAGGAACTG GCGAGTCTCT CCCGCACAAT
 180
 CAAGCCGGCG AAATCTGCAT CCGCGGACCC GAAATAATGA AAGGATATAT TAACGACCCG
 240
 GAATCCACGG CCGCTACAAT CGATGAAGAA GGCTGGCTCC ACACAGGCGA CGTCGGGTAC
 300
 ATTGACGATG ACGAAGAAAT CTTCATAGTC GACAGAGTAA AGGAGATTAT CAATATAAAG
 360
 GCTTCCAGGT GGATCCTGCT AATCGAATTC CTGCAGCCCCG GGGGTCCACT AGTTCTAGAG
 420
 CGGCCGCCAC CGCGGTGGAG CTCCAGCTTT TGT
 453

(2) INFORMATION FOR SEQ ID NO:13:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 278 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:13:

TCTTCGAATT CTCTTTCACG ACTGCTTCGT TAATGGCTGC GATGGCTCGA TATTGTTAGA
 60
 TGATAACTCA ACGTTCACCG GAGAAAAGAC TGCAGGCCCA AATGTTAATT CTGCGAGAGG
 120

ATTCGACGTA ATAGACACCA TCAAAACTCA AGTTGAGGCA GCCTGCAGTG GTGTCGTGTC
 180
 AGTTGCCGAC ATTCTCGCCA TTGCTGCACG CGATTTCAGTC GTCCAACTGG GGGGCCCCAAC
 240
 ATGGACGGTA CTTCTGGGAG AAAAGACGGA TCCGATCA
 278

(2) INFORMATION FOR SEQ ID NO:14:

- (i) SEQUENCE CHARACTERISTICS:
 (A) LENGTH: 23 base pairs
 (B) TYPE: nucleic acid
 (C) STRANDEDNESS: single
 (D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:14:

CTTCGAATTC WYTTYCAYGA YTG
 23

(2) INFORMATION FOR SEQ ID NO:15:

- (i) SEQUENCE CHARACTERISTICS:
 (A) LENGTH: 22 base pairs
 (B) TYPE: nucleic acid
 (C) STRANDEDNESS: single
 (D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:15:

GATCGGATCC RTCYYKYCTY CC
 22

(2) INFORMATION FOR SEQ ID NO:16:

- (i) SEQUENCE CHARACTERISTICS:
 (A) LENGTH: 472 base pairs
 (B) TYPE: nucleic acid
 (C) STRANDEDNESS: single
 (D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:16:

AATTCGGCAC GAGACGACCT CTTGTATCGG ACCCGGATCC GCTATCGTTA ACGTACACAC
 60
 GTTCTAGTGC TGAATGGAGA TGGAGAGCAC CACCGGCACC GGCAACGGCC TTCACAGCCT
 120
 CTGCGCCGCC GGGAGCCACC ATGCCGACCC ACTGAACTGG GGGCGGGCGG CAGCAGCCCT
 180
 CACAGGGAGC CACCTCGACG AGGTGAAGCG GATGGTCGAG GAGTACCGGA GGCCGGCGGT
 240
 GCGCCTCGGC GGGGAGTCCC TCACGATAGC CCAGGTGGCG GCGGTGGCGA GTCAGGAGGG
 300
 GGTAGGGGTC GAGCTCTCGG AGGCGGCCCC TCCCAGGGTC AAGGCCAGCA GCGACTGGGT
 360
 CATGGAGAGC ATGAACAAGG GAACTGACAG CTACGGGGTC ACCACCGGGT TCGGCGGCAA
 420
 CTTCTCAAAC CGGAGGCCGA AGCAAGGCG TCCTTTTCAG AAGGAACTTA TA
 472

(2) INFORMATION FOR SEQ ID NO:17:

- (i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 622 base pairs
 (B) TYPE: nucleic acid
 (C) STRANDEDNESS: single
 (D) TOPOLOGY: linear

(x1) SEQUENCE DESCRIPTION: SEQ ID NO:17:

CCAAAGCTCC TAGTGCCTCA TGAGTCTGCT GAGGATTGCA CAATTGGCGG GTTCGACGTG
 60
 CCCCAGGGCA CCATGATCCT GGTTAATGCC TGGGCAATTC AAAGAGACCC AAAAGTGTGG
 120
 GACGATCCCA CAAATTTTAA ACCGGAGAGG TACGAGGGAT TGAAGGTGA TCATGCCTAC
 180
 CGACTATTGC CGTTTGGGAT GGGGAGGAGA AGTTGTCCTG GTGCTGGCCT TGCCAATAGA
 240
 GTGGTGAGCT TGGTCTGGC GGCCTTATT CAGTGCTTCG AATGGGAACG AGTTGGCGAA
 300
 GAATTGGTGG ACTTGTCCGA GGGGACGGGA CTCACAATGC CAAAGAGAGA GCCATTGGAG
 360
 GCCTTGTGCA AAGCGCGTGA ATGCATGATA GCTAATGTTC TTGCGCACCT TTAAGAAGGT
 420
 CGTTGTCTAA TGAATTTACA TTGGTGATGT ATCTCCAATG TTTTGAATA ATCAAATAGA
 480
 CTGAAAATAG GCCAGTGCAG CTTTAGGAAT GATCGTGAGC ATCAATAGCA TCCTGAGGAG
 540
 GCCAATGCAG CTTTAGGCCT TTCTCTTAGG AGAAAAATGA TGGTTTATAT AGGTACTGGC
 600
 AACATTGTTC AAAAAAAAAA AA
 622

(2) INFORMATION FOR SEQ ID NO:18:

(i) SEQUENCE CHARACTERISTICS:
 (A) LENGTH: 414 base pairs
 (B) TYPE: nucleic acid
 (C) STRANDEDNESS: single
 (D) TOPOLOGY: linear

(x1) SEQUENCE DESCRIPTION: SEQ ID NO:18:

CACGCTCGAC GAATTCGGTA CCCCGGGTTC GAAATCGATA AGCTTGGATC CAAAGCAACA
 60
 CATTGAACTC TCTCTCTCTC TCTCTCTCTC TCTCTCTCTC TCCCCACCC CCCCTTCCCA
 120
 ACCCCACCCA CATAAGACA AGTAGATACG CGCACACAGA AGAAGAAAAG ATGGGGGTTT
 180
 CAATGCAGTC AATCGCACTA GCGACGGTTC TGGCCGTCCT AACGACATGG GCGTGGAGGG
 240
 CGGTGAACTG GGTGTGGCTG AGGCCGAAGA GGCTCGAGAG GCTTCTGAGA CAGCAAGGTC
 300
 TCTCCGGCAA GTCCTACACC TTCCTGGTCG GCGACCTCAA GGAGAACCTG CGGATGCTCA
 360
 AGGAAGCCAA GTCCAAGCCC ATCGCCGTCT CCGATGACAT CAAGCCTCGT CTCT
 414

(2) INFORMATION FOR SEQ ID NO:19:

(i) SEQUENCE CHARACTERISTICS:
 (A) LENGTH: 469 base pairs
 (B) TYPE: nucleic acid
 (C) STRANDEDNESS: single
 (D) TOPOLOGY: linear

(x1) SEQUENCE DESCRIPTION: SEQ ID NO:19:

GAATTCCGGCA CGAGTGTCTC TCTCTCTCTC TCTCTCTGTA AACCACCATG CTCTTCTCA
 60
 CTCATCTCCT AGCAGTTCTA GGGGTTGTST TGCTCCTGCT AATTCTATGG AGGGCAAGAT
 120
 CTTCTCCGAA CAAACCCAAA GGTACTGCCT TACCCCGGGA GCTGCCGGGC GCATGGCCGA
 180
 TCATAGGCCA CATCCACTTG CTGGGCGGCG AGACCCCGCT GGCCAGGACC CTGGCCGCCA
 240
 TGGCGGACAA GCAGGGCCCG ATGTTTCGGA TCCGTCTCGG AGTCCACCCG GCGACCATCA
 300
 TAAGCAGCCG TGAGGCGGTC CGGGAGTGCT TCACCACCCA CGACAAGGAC CTCGCTTCTC
 360
 GCCCCAAATC CAAGGCGGGA ATCCACTTGG GCTACGGGTA TGCCGGTTTT GGCTTCGTAG
 420
 AATACGGGGA CTTTGGGCG GAGATGAGGA AGATCACCAT GCTCGAGCT
 469

(2) INFORMATION FOR SEQ ID NO:20:

(1) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 341 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(x1) SEQUENCE DESCRIPTION: SEQ ID NO:20:

CGGGCTCGTG GCTCGGCTCC GGCGCAACGC CCTTCCCACC GGGCCCGAGG GGCCTCCCGG
 60
 TCATCGGGAA CATGCTCATG ATGGGCGAGC TCACCCACCG CGGCCTCGCG AGTCTGGCGA
 120
 AGAAGTATGG CGGGATCTTC CACCTCCGCA TGGGCTTCCT GCACATGGTT GCCGTGTCGT
 180
 CCCCCGACGT GGCCCGCCAG GTCCCTCCAGG TCCACGACGG GATCTTCTCG AACCGGCCTG
 240
 CCACCATCGC GATCAGCTAC CTCACGTATG ACCGGGCCGA CATGGCCTTC GCGCACTACG
 300
 GCCCGTTCTG GCGGCAGATG CGGAAGCTGT GCGTGATGAA A
 341

(2) INFORMATION FOR SEQ ID NO:21:

(1) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 387 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(x1) SEQUENCE DESCRIPTION: SEQ ID NO:21:

GAATTCCGGCA CGAGCGGGCT CGTGGCTCGG CTCCGGCGCA ACGCCCTTCC CACCGGGCCC
 60
 GAGGGGCCTC CCGGTCATCG GGAACATGCT CATGATGGGC GAGCTCACC ACCGCGGCCT
 120
 CGCGAGTCTG GCGAAGAAGT ATGGCGGGAT CTTCCACCTC CGCATGGGCT TCCTGCACAT
 180
 GGTTCGCGTG TCGTCCCCCG ACGTGGCCCG CCAGGTCCCTC CAGGTCCACG ACGGGATCTT
 240
 CTCGAACCGG COTGCCACCA TCGCGATCAG CTACCTCAG TATGACCGGG CCGACATGGC
 300
 CTTGCGCAC TACGGCCCGT TCTGGCGGCA GATGCGGAAG CTGTGCGTGA TGAAAGCTCT
 360

TCAGCGGAAG CGGGCTGAGT CGTGGA
387

(2) INFORMATION FOR SEQ ID NO:22:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 443 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:22:

CACGAGCTCG TGAGCCTTCC GGGAGACAAG GCCATCTTAC TTGCAACAA ATTGCGTCCG
60
CACTCCTTTC TCAAGAAACC TAGTCATCCA AGAAGCAGAG CATTGCAACT GCAAACAGCC
120
AAAGCCCCAA CTCGTACAGA AGGAGAGAGA GAGAGAGAAT AGAAGCATGA GTGCATGCAC
180
GAACCAAGCA ATCACGACGG CCAGTGAAGA TGAAGAGTTC TTGTTGCCA TGGAAATGAA
240
TGCTCTGATA GCACTCCCCT TGGTCTTGAA GGCCACCATC GAACTGGGGA TCCTCGAAAT
300
ACTGGCCGAG TGGGGGCTA TGGCTCCACT TTCGCCTGCT CAGATTGCCT CCCGTCTCTC
360
CGCAAAGAAC CCGGAAGCCC CCGTAACCCT TGACCGGATC CTCCGGTTTC TCGCCAGCTA
420
CTCCATCCTC TCTTGCACTC TCG
443

(2) INFORMATION FOR SEQ ID NO:23:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 607 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:23:

GAATTCGGCA CGAGCCAACC CTGGACCAGG TACTTTTGGC AGGCGGTCCA TTGCCCTTCA
60
AACCGGTCCA AACCGGACCA TCACTGTCCT TATATACGTT GCATCATGCC TGCTCATAGA
120
ACTTAGGTCA ACTGCAACAT TTCTTGATCA CAACATATTA CAATATTCTT AAGCAGAGAG
180
AGAGAGAGAG AGAGAGAGAG AGAGAGAGAG AGAGTTTGAA TCAATGGCCA CCGCCGGAGA
240
GGAGAGCCAG ACCCAAGCCG GGAGGCACCA GGAGGTGGC CACAAGTCTC TCCTTCAGAG
300
TGATGCTCTT TACCAATATA TTTTGGAGAC CAGCGTGTAC CCAAGAGAGC CTGAGCCCAT
360
GAAGGAGCTC AGGGAAATAA CAGCAAAACA TCCATGGAAC ATAATGACAA CATCAGCAGA
420
CGAAGGGCAG TTCTTGAACA TGCTTCTCAA GCTCATCAA GCCAAGAACA CCATGGAGAT
480
TGGTGTCTTC ACTGGCTACT CTCTCCTCGC CACCGCTCTT GCTCTTCCTG ATGACGGAAA
540
GATTTTGGCT ATGGACATTA ACAGAGAGAG CTATGAACTT GGCCTGCCGG CATCCAAAAA
600
GCCGGTG
607

(2) INFORMATION FOR SEQ ID NO:24:

(1) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 421 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(x1) SEQUENCE DESCRIPTION: SEQ ID NO:24:

```

GAATTCGGCA CGAGCCGTTT TATTTCTCTT GATTCCTTT GCTCGAGTCT CGCGGAAGAG
60
AGAGAAGAGA GGAGAGGAGA GAATGGGTTT GACCGGATCC GAGACCCAGA TGACCCCGAC
120
CCAAGTCTCG GACGAGGAGG CGAACCTCTT CGCCATGCAG CTGGCGAGCG CCTCCGTGCT
180
CCCCATGGTC CTCAAGGCCG CCATCGAGCT CGACCTCTC GAGATCATGG CCAAGGCCGG
240
GCCGGGCGCG TTCCTCTCCC CGGGGGAAGT CGCGGCCAG CTCCGACCC AGAACCCCGA
300
GGCACCCGTA ATGCTCGACC GGATCTTCCG GCTGCTGGCC AGCTACTCCG TGCTCACGTG
360
CACCTCCGC GACCTCCCCG ATGGCAAGST CGAGCGGCTC TACGGCTTAG CGCCGGTGTG
420
C
421

```

(2) INFORMATION FOR SEQ ID NO:25:

(1) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 760 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(x1) SEQUENCE DESCRIPTION: SEQ ID NO:25:

```

GGAAGAAGCC GAGCAAACGA ATTGCAGACG CCATTGAAAA AAGACACGAA AGAGATCAAG
60
AAGGAGCTTA AGAAGCATCA TCAATGGCAG CCAACGCAGA GCCTCAGCAG ACCCAACCAG
120
CGAAGCATTC GGAAGTCGGC CACAAGAGCC TCTTGCAGAG CGATGCTCTC TACCAGTATA
180
TATTGGAGAC CAGCGTCTAC CCAAGAGAGC CAGAGCCCAT GAAGGAGCTC AGGGAAATAA
240
CAGCCAAACA TCCATGGAAC CTGATGACCA CATCGGCGGA TGAAGGGCAG TTCCTGAACA
300
TGCTCCTCAA GTCATCAAC GCCAAGAACA CCATGGAGAT CGGCGTCTAC ACCGGCTACT
360
CTCTCCTCGC AACCGCCCTT GCTCTTCCCG ATGACGGAAA GATCTTGGCC ATGGCCATCA
420
ATAGGGAGAA CTTGAGATC GGGCTGCCCG TCATCCAGAA GGCCGGCCTT GCCACAAGA
480
TCGATTTTCA AGAAGGCCCT GCCCTGCCGC TCCTTGATCA GCTCGTGCAA GATGAGAAGA
540
ACCATGGAAC GTACGACTTC TTCTCAATCC TTAATCGTTC ATTTGAATAC AAATACATGC
600
TCAATGGTTC AAAGACAACA TAAGACAGAA GATGGAAAAA ATAGAAAGGA AGGAAAGTAT
660
TAAGGGTAGT TTCTCATTTT ATCAATGCTT GATTTTGAGA TCTCCTTTCT GGTGCGATCA
720
GCTGACCCGG CGGCACAGGT GATGCCATCC CCGACGGGAA
760

```

(2) INFORMATION FOR SEQ ID NO:26:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 508 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:26:

GAATTCGGTA CCCGGGTTTCG AAATCGATAA GCTTGGATCC AAAGAATTTCG GCACGAGATC
60
ACTAACCATC TGCCTTTCTT CATCTTCTTT CTCTGCTTC TCCTCCGTTT CCTCGTTTCG
120
ATATCGTGAA AGGAGTCCGT CGACGACAAT GGCCGAGAAG AGCAAGGTCC TGATCATCGG
180
AGGGACGGGC TACGTCGGCA AGTTCATCGT GGAAGCGAGT GCAAAAGCAG GGCATCCCAC
240
GTTTCGCGCTG GTTAGGCAGA GCACGGTCTC CGACCCCGTC AAGGGCCAGC TCGTCGAGAG
300
CTTCAAGAAC TTGGGCGTCA CTCTGCTCAT CGGTGATCTG TACGATCATG AGAGCTTGGT
360
GAAGGCAATC AAGCAAGCCG ACGTGGTGAT ATCGACAGTG GGGCACATGC AAATGGCCGA
420
TCAGACCAAA GAATCGTCGA CGCCATTAA GGAAGCTGGC AACGTTAAGG TTTGTTGGTT
480
GGTTCATTTG ATCTGTTTTG GGGGGGTC
508

(2) INFORMATION FOR SEQ ID NO:27:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 495 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:27:

GAATTCGGCA CGAGGTTAAT GGCAGTGCAG CCTCAACACC ACCCACCTTC CTCCATCTCT
60
CTCCTCCCTT CTTCTTTCTC TGACTTCAAT GGCAGCCGAC TCCATGCTTG CGTTCAGTAT
120
AAGAGGAAGG TGGGGCAGCC TAAAGGGGCA CTGCGGGTCA CTGCATCAAG CAATAAGAAG
180
ATCCTCATCA TGGGAGGCAC CCGTTTCATC GGTGTGTTTT TGTCGAGACT ACTTGTCAAA
240
GAAGGTCATC AGGTCACTTT GTTTACCAGA GGAAGAGCAC CCATCACTCA ACAATTGCCT
300
GGTGAGTCGG ACAAGGACTT CGCTGATTTT TCATCCAAGA TCCTGCATTT GAAAGGAGAC
360
AGAAAGGATT TTGATTTTGT TAAATCTAGT CTTGCTGCAG AAGGCTTTGA CGTTGTTTAT
420
GACATTAACG GCGAGAGGCG GATGAAGTCG CACCAATTTT GGATGCCTGC CAAACCTTGA
480
ACCAAGTCAAC TACTG
495

(2) INFORMATION FOR SEQ ID NO:28:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 472 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:28:

GAATTCGGCA CGAGCATAAG CTCTCCCGTA ATCCTCACAT CACATGGCGA AGAGCAAGGT
60
CCTCGTCGTT GGCGGCACTG GCTACCTCGG GCGGAGGTTT GTGAGGGCGA GCCTGGACCA
120
GGGCCACCCC ACGTACGTCC TCCAGCGTCC GGAGACCGGC CTCGACATTG AGAAGCTCCA
180
GACGCTACTG CGCTTCAAGA GGCCTGGCGC CCAACTCCTC GAGGCCTCGT TCTCAGACCT
240
GAGGAGCCTC GTCGACGCTG TGAGGCGGGT CGATGTCGTC GTCTGTGCCA TGTCGGGGGT
300
CCACTTCCGG AGCCACAACA TCCTGATGCA GCTCAAGCTC GTGGAGGCTA TCAAAGAAGC
360
TGGAATGTC AAGCGSTTTT TGCCGTCAGA GTTCGGAATG GACCCGGCCC TCATGGGTCA
420
TGCAATTGAG CCGGAAGGG TCACGTTCTG TGAGAAATGG AGGTGAGAAA AG
472

(2) INFORMATION FOR SEQ ID NO:29:

(1) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 396 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:29:

GAATTCGGCA CGAGGAGGCA CCTCCTCGAA ACGAAGAAGA AGAAGGACGA AGGACGAAGG
60
AGACGAAGGC GAGAAATGAGC GCGGCGGGCG GTGCCGGGAA GGTCTGTGTC GTGACCGGGG
120
CGTCCGGTTA CATCGCCTCG TGGCTCGTCA AGCTCCTCCT CCAGCGCGGC TACACCGTCA
180
AGGCCACCGT CCGCGATCCG AATGATCCAA AAAAGACTGA ACATTTGCTT GGACTTGATG
240
GAGCGAAAGA TAGACTTCAA CTGTTCAAAG CAAACCTGCT GGAAGAGGGT TCATTTGATC
300
CTATTGTTGA GGGTTGTGCA GGCCTTTTTT AACTGCCTC TCCCTTTTAT CATGATGTCA
360
AGGATCCGCA GGCAGAATTA CTTGATCCGG CTGTAA
396

(2) INFORMATION FOR SEQ ID NO:30:

(1) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 592 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:30:

GAATTCGGCA CGAGGTTGAA CCTCCCGTCC TCGGCTCTGC TCGGCTCTGC ACCCTCTTCG
60
CGCTCCCGCA TACTCCACCA CCGCGTACAG AAGATGAGCT CGGAGGGTGG GAAGGAGGAT
120
TGCCTCGGTT GGGCTGCCCC GGACCCTTCT GGGTTCCTCT CCCCCTACAA ATTCACCCGC
180
AGGGCCGTGG GAAGCGAAGA CGTCTCGATT AAGATCAGC ACTGTGGAGT GTGCTACGCA
240

GATGTGGCTT GGACTAGGAA TGTGCAGGGA CACTCCAAST ATCCTCTGGT TCCAGGGCAC
 300
 GAGATAGTTG GAATTGTGAA ACAGGTTGGC TCCAGTGTCC AACGCTTCAA AGTTGGCGAT
 360
 CATGTGGGGG TGGGAACCTA TGTCAATTCA TGCAGAGAGT GCGAGTATTG CAATGACAGG
 420
 CTAGAAGTCC AATGTGAAAA GTCGGTTATG ACTTTTGATG GAATTGATGC AGATGGTACA
 480
 GTGACAAAGG GAGGATATTC TAGTCACATT GTCGTCCATG AAAGGTATTG CCTCAGGATT
 540
 CCAGAAACT ACCCGATGGA TCTAGCAGCG CATTTGCTCT GTGCTGGATC AC
 592

(2) INFORMATION FOR SEQ ID NO:31:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 468 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:31:

GAATTCGGCA CGAGAACTCA TCTTGAAATG TCATTGGAGT CATCATCCTC TAGTGAGAAG
 60
 AAACAAATGG GTTCCGCCGG ATTGGAATCG GCCACAAAGC CGCAGGCCGT TTGCATTCCC
 120
 TACCCTGCAC AAAGCCACAT TGGCGCCATG CTCAAGCTAG CAAAGCTCCT CCATCACAAG
 180
 GGCTTCCACA TCTCCTTCGT CAACACCGAG TTCAACCACC GCGGGCTCGC CAGGGGCTCGA
 240
 GGCCCCGAGT TCACAAATGG AATGCTGAGC GACTTTCAGT TCCTGACAAT CCCCAGTGGT
 300
 CTTCTCCTT CGGACTTGGA TCGATCCAA GACATCAAGA TCCTCTGCGA ATCGTCCAGG
 360
 AACTATATGG TCAGCCCCAT CAACGATCTT GTATCGAGCC TGGGCTCGAA CCCGAGCGTC
 420
 CTTCCGGTGA CTTGCATCAA TCTCGGATGG TTTCATGACA CTCGTGAC
 468

(2) INFORMATION FOR SEQ ID NO:32:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 405 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:32:

CTTTACTCCG CCAAGAAGAT CCAATCGCAG TTTTCGCAAT TGGCCCATTA CACAAATGCG
 60
 GTCCATCTTC ATCGGGAAGT CTCTTGGCAG AAGACCGGAG TTGCATTTC TGGCTGGACA
 120
 AGCAAGCCCC TAACTCAGTG GTCTATGTGA GTCTTGGGAG CATCGCCTCT GTGAACGAGT
 180
 CGGAATTTTC CGAAATAGCT TTAGGTTTAG CCGATAGCCA GCAGCCATTC TTGTGGGTGG
 240
 TTCGACCCGG GTCAGTGAGC GGCTCGGAAC TCTTAGAGAA TTTGCCCGGT TGCTTTCTGG
 300
 AGGCATTACA GGAGAGGGGG AAGATTGTGA AATGGGCGCC TCAACATGAA GTGCTGGCTC
 360
 ATCGGGCTGT CGGAGCGTTT TGGACTCACA ATGGATGGAA CTCCA
 405

(2) INFORMATION FOR SEQ ID NO:33:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 380 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:33:

GGCAAACACG CCCGTTTTCS TTTTACTAAG AGAAGATGGT GAGCGITGTG GCTGGTAGAG
 60
 TCGAGAGCTT GTCGAGCAGT GGCATTGAGT CGATCCCGCA GGAGTATGTG AGGCCGAAGG
 120
 AGGAGCTCAC AAGCATTGGC GACATCTTCS AGGAGGAGAA GAAGCATGAG GGCCCTCAGG
 180
 TCCCGACCAT CGACCTCGAG GACATAGCGT CTAAAGACCC CGTGGTGAGG GAGAGGTGCC
 240
 ACGAGGAGCT CAGGAAGGCT GCCACCGACT GGGGCGTCAT GCACCTCGTC AACCATGGGA
 300
 TCCCCAACGA CCTGATTGAG CGTGTAAGA AGGCTGGCGA GGTGTTCTTC AACCTCCCGA
 360
 TCGAGGAGAA GGACAAGCAT
 380

(2) INFORMATION FOR SEQ ID NO:34:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 305 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:34:

TTGTACCCGA AGATCTCCGG GACCGTTCSA CGGCGACATC GCCGTGGGCC GGGAACCCGT
 60
 CGAGGCCGCC GCCGGAGGCC GGGGAGAAGC TGGAGTAGCC GCCGTAGCCG GAGAAGGCCG
 120
 CGTCGTGGTC GGCGGCGGCG GCGTGGTGGA CCTCATCGCC GTCCATGCTG AAGGCGTCSA
 180
 AGGAAGCGGA CATGGCTGGG GGATCGATCG ACCGATCCGA TCGGCCGGAG GATTTCGAGA
 240
 TCGGAGATGG AGAGATGGAA ATGAAAGAGA GAGAGAGAGA GAGATCCGGT GGA CTGGTG
 300
 TGTTT
 305

(2) INFORMATION FOR SEQ ID NO:35:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 693 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:35:

GAATTCGGCA CGAGCTAAGA GAGGAGAGGA GAGGAGCAAG ATGGCACTAG CAGGAGCTGC
 60
 ACTGTCAGGA ACCGTGGTGA GCTCCCCCTT TGTGAGGATG CAGCCTGTGA ACAGACTCAG
 120

GGCATTCCCC AATGTGGGTC AGGCCCTGTT TGGTGTCAAC TCTGGCCGTG GCAGAGTGAC
 180
 TGCCATGGCC GCTTACAAGG TCACCCTGCT CACCCCTGAA GGCAAAGTCG AACTCGACGT
 240
 CCCCACGAT GTTTACATCT TGGACTACGC CGAGGAGCAG GGCATCGACT TSCCCTACTC
 300
 CTGCCGTGCC GGCTCTTGCT CCTCCTGCGC GGGCAAGGTC GTGGCGGGGA GCGTCGACCA
 360
 GAGCGACGGC AGCTTCCTGG ATGATGATCA GATTGAGGAA GGTGGGTCC TCACTTGTGT
 420
 CGCCTACCCT AAGTCTGAGG TCACCATTGA GACCCACAAG GAAGAGGAGC TCACTGCTTG
 480
 AAGCTCTCCT ATATTTGCTT TTGCATAAAT CAGTCTCACT CTACGCAACT TTCTCCACTC
 540
 TCTCCCCCT TCACTACATG TTTGTTAGTT CCTTTAGTCT CTTCTTTTT TACTGTACGA
 600
 GGGATGATTT GATGTTATTC TGAGTCTAAT GTAATGGCTT TTCTTTTTCC TATTTCTGTA
 660
 TGAGGAAATA AAATCATGC TCTAAAAAA AAA
 693

(2) INFORMATION FOR SEQ ID NO:36:

(1) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 418 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:36:

AGGACTTTAT TATAAGCATT GTAAAAAGAG TCAAATAAT ACATCGCAAG AATTGGGTTA
 60
 TCCAATAATC TACAAAAAGA AAAAAGTTTG ATGCATTGAG ATGGTAACTG CTTAATTCAA
 120
 ATGCCTTAGT TTGAAAAATT AACCAACTAT TAAATTAAT GATGATGAAT ATGGATTATG
 180
 TGTGAAAAAC TATATAGACT TAAATTGAC TCAGAAGACA TTCTTTTCTT CTTATTTTAT
 240
 GATATGATGA ATTCGGTCTA AACAGGCAAA TGGTGTCAAA CGGGAAGTCG GCAAAACTCT
 300
 TCCTCGGCAG TGAATACCGG GCGGGCGATG ATGCGGATCC GGGGGCCGGG TCGCTGGAGA
 360
 ACATCCCGCA CGGACCGGTC CACGTTTGGT GCGGTGACAA CAGGCAGCCC AACCTGGA
 418

(2) INFORMATION FOR SEQ ID NO:37:

(1) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 777 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:37:

GAATTCGGCA CGAGCATACA ACTACACTGC GACGCCGCCG CAGAACGCGA GCGTGCCGAC
 60
 CATGAACGGC ACCAAGGTCT ACCGGTTGCC GTATAACGCT ACGGTCCAGC TCGTTTTACA
 120
 GGACACCGGG ATAATCGCGC CGGAGACCCA CCCCATCCAT CTGCACGGAT TCAACTTCTT
 180
 CCGTGTGGGC AAAGGAGTGG GGAATTATGA CCCAAAGAAG GATCCCAAGA AGTTCAATCT
 240

GGTTGACCCA GTGGAGAGGA ACACCATTGG AATCCCATCT GGTGGATGGA TAGCCATCAG
 300
 ATTCACAGCA GACAATCCAG GAGTTTGGTT CCTGCACTGC CATCTGGAAG TGCACACAAC
 360
 TTGGGGACTG AAGATGGCAT TCTTGGTGGA CAATGGGAAG GGGCCTAAAG AGACCCTGCT
 420
 TCCACCTCCA AGTGATCTTC CAAAATGTTG ATCATTTGAT CATGAGGACG ACAAGCGATT
 480
 ACTAATGACA CCAAGTTAGT GGAATCTTCT CTTTGAAAAA GAAGAAGAAG AGCAAGAAGA
 540
 ATAAGAAAGA TGAGGAGAGA AGCCATAGAA GATTTGACCA AGAAGAGAGA GGGCAATAAA
 600
 CCAAAGAGAC CCTTGAGATC ACGACATCCC GCAATTGTTT CTAGAGTAAT AGAAGGATTT
 660
 ACTCCGACAC TGCTACAATA AATTAAGGAA GACAAGGAAT TTGGTTTTTT TCATTGGAGG
 720
 AGTGTAATTT GTTTTTTGGC AAGCTCATCA CATGAATCAC ATGGAAAAAA AAAAAA
 777

(2) INFORMATION FOR SEQ ID NO:38:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 344 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:38:

ATATGTTTCA AATTTCAAAT GTGGGAATGT CAACCTCCTT GAACTTCAGA ATTCAGGGCC
 60
 ATACGTTGAA GCTAGTCGAG GTTGAAGGAT CTCACACCGT CCAGAACATG TATGATTCAA
 120
 TCGATGTTCA CGTGGGCCAA TCCATGGCTG TCTTAGTGAC CTAAATCAG CCTCCAAAGG
 180
 ACTACTACAT TGTCCGATCC ACCCGGTTCA CCAAGACGGT TCTCAATGCA ACTGCAGTGC
 240
 TACTACTACAC CAACTCGCTT ACCCCAGTTT CCGGGCCACT ACCAGCTGGT CCAACTTACC
 300
 AAAAACATTG GTCCATGAAG CAAGCAAGAA CAATCAGGTS GAAC
 344

(2) INFORMATION FOR SEQ ID NO:39:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 341 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:39:

GCCGCAACTG CAATTCTCTT CGTAAACAT GACGGCTGTC GGCAAAACCT CTTTCCTCTT
 60
 GGGAGCTCTC CTCCTCTTCT CTGTGGCGGT GACATTGGCA GATGCAAAAG TTTACTACCA
 120
 TGATTTTGTC GTTCAAGCGA CCAAGGTGAA GAGGCTGTGC ACGACCCACA ACACCATCAC
 180
 GGTGAACGGG CAATTCCCGG GTCCGACTTT GGAAGTTAAC GACGGCGACA CCCTCGTTGT
 240
 CAATGTCGTC AACAAAGCTC GCTACAACGT CACCATTAC TGGCACGGCG TCCGGCAGGT
 300
 GAGATCTGCT TGGGCTGATG GGGCGGAATT TGTGACTCAA T
 341

(2) INFORMATION FOR SEQ ID NO:40:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 358 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:40:

GAATTCGGCA CGAGATATGT TCAGAATTTT AAATGTGGGA ATGTCAACCT CCTTGAACCT
60
CAGAATTCAG GGCCATACGT TGAAGCTAGT CGAGGTTGAA GGATCTCACA CCGTCCAGAA
120
CATGTATGAT TCAATCGATG TTCACGTGGG CCAATCCATG GCTGTCTTAG TGACCTTAAA
180
TCAGCCTCCA AAGGACTACT ACATTGTCGC ATCCACCCGG TTCACCAAGA CGGTTCTCAA
240
TGCAACTGCA GTGCTACACT ACACCAACTC GCTTACCCCA GTTTCCGGGC CACTACCAGC
300
TGGTCCAACT TACCAAAAAC ATTGGTCCAT GAAGCAAGCA AGAACAATCA GGTGGAAC
358

(2) INFORMATION FOR SEQ ID NO:41:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 409 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:41:

ATCAAGAGTT TGAGTCTAAA CCTTGTCTAA TCCTCTCTCG CATAGTCATT TGGAGACGAA
60
TGCTGATCGG CCGCAGCTGC ATTCTCTTCG TAAAACATGA CGGCTGTCTG CAAAACCTCT
120
TTCTCTTGG GAGCTCTCCT CCTCTTCTCT GTGGCGGTGA CATTGGCAGA TGCAAAAGTT
180
TACTACCATG ATTTTGTCTG TCAAGCGACC AAGGTGAAGA GGCTGTGCAC GACCCACAAC
240
ACCATCACGG TGAACGGGCA ATTCCCGGGT CCGACTTTGG AAGTTAACGA CGGCGACACC
300
CTCGTTGTCA ATGTCGTCAA CAAAGCTCGC TACAACGTCA CCATTCACTG GCACGGCGTC
360
CGGCAGGTGA GATCTGGTTG GGCTGATGGG GCGGAATTTG TGA CTCAAT
409

(2) INFORMATION FOR SEQ ID NO:42:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 515 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:42:

CTCTCTCTCT CTCTCTCTCT GTGTGTTTAT TCTCGTTGAG CTCGTGGTCG CCTCCCGCCA
60
TGGATCCGCA CAAGTACCGT CCATCCAGTG CTTTCAACAC TTCTTTCTGG ACTACGAACT
120

CTGGTGCTCC TGTCTGGAAC AATAACTCTT CGTTGACTGT TGGAGGAGA GGTCCAATTC
 180
 TTCTTGAGGA TTATCACCTC GTGGAGAAAC TTGCCAACTT TGATAGGGAG AGGATTCCAG
 240
 AGCGTGTTGGT GCATGCCAGA GGAGCCAGTG CAAAGGGATT CTTTGAGGTC ACTCATGACA
 300
 TTTCCCAGCT TACCTGTGCT GATTTCTTTC GGGCACCAGG AGTTCAAACA CCGGTGATTG
 360
 TCCGTTTCTC CACTGTCATC CACGAAAGGG GCAGCCCTGA AACCTGAGG GACCCCTGAG
 420
 GTTTTGCTGT GAAGTTCTAC ACAAGAGAGG GTAACCTTGA TCTGGTGGGA AACAAATTTCC
 480
 CTGTCTTCTT TGTCCGTAAT GGGATAAATT CCCCC
 515

(2) INFORMATION FOR SEQ ID NO:43:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 471 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:43:

GAATTCGGCA CGAGGCTCCC TCTCGTACTG CCATACTCCT GGGACGGGAT TCGGATAGGG
 60
 ATTTGCGGCG ATCCATTTCT CGATTCAAGG GGAAGAATCA TGGGGAAGTC CTACCCGACC
 120
 GTAAGCCAGG AGTACAAGAA GGCTGTGAG AAATGCAAGA AGAAGTTGAG AGGCCTCATC
 180
 GCTGAGAAGA GCTGCGCTCC GCTCATGCTC CGCATCGCGT GGCACCTCCG CCGTACCTTC
 240
 GATGTGAAGA CGAAGACCGG AGGCCCGTTC GGGACCATGA AGCACGCCGC GGAGCTCAGC
 300
 CACGGGGCCA ACAGCGGGCT CGACGTTGCC GATCAGGTCT TGCAGCCGAT CAAGGATCAG
 360
 TTCCCCGTCA TCACTTATGC TGATTTCTAC CAGCTGGCTG GCGTCGTTGC TGTGGAAGTT
 420
 ACTGGTGGAC CTGAAGTTGC TTTTCACCCG GAAGAGAGGC AAACCACAAC C
 471

(2) INFORMATION FOR SEQ ID NO:44:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 487 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:44:

GAATTCGGCA CGAGCTCCCA CTTCTGTCTC GCCACCATTA CTAGCTTCAA AGCCCAGATC
 60
 TCAGTTTCGT GCTCTCTTCG TCATCTCTGC CTCTTGCCAT GGATCCGTAC AAGTATCGCC
 120
 CGTCCAGCGC TTACGATTCC AGCTTTTGGA CAACCAACTA CCGTGCTCCC GTCTGGAACA
 180
 ATGACTCATC GCTGACTGTT GGAAGTAGAG GTCCGATTCT CCTGGAGGAC TACCATCTGA
 240
 TTGAGAAACT TGCCAACTTC GAGAGAGAGA GGATTCCTGA GCGGGTGGTC CATGCACGGG
 300
 GAGCCAGCGC GAAAGGGTTC TTCGAGGTCA CCCACGACAT CTCTCACTTG ACCTGTGCTG
 360

ATTTCTCTCG GGCTCCTGGA GTCCAGACGC CCGTAATCGT CCGTTTCTCC ACGTCATCC
 420
 ACGAGCGCGG CAGCCCGAAC CTCAGGGACC CTCGTGGTTT TGCAGTGAAG TTCTACACCA
 480
 GAGAGGG
 487

(2) INFORMATION FOR SEQ ID NO:45:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 684 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:45:

GAATTCCTGC AGCCCGGGGG ATCCACTAGT TCTAGAGCGG CCGCCACCGC GSTGGAGCTC
 60
 GCGCGCCTSC AGGTCGACAC TAGTGGATCC AAAGAATTCC GCACGAGGCC CGACGGCCAC
 120
 TTGTTGGACG CCATGGAAGC TCTCCGAAA GCCGGGATTC TGGAAACGTT TAAACTGCAG
 180
 CCCAAGGAAG GACTGGCTCT CGTCAACGGC ACAGCGGTGG GATCCGCCGT GCCCGCGTCC
 240
 GTCTGTTTTG ACGCCAACGT GCTGGGCGTG CTGGCTGAGA TTCTGTCTGC GCTCTTCTGC
 300
 GAGGTGATGC AAGGGAAACC GGAGTTCGTA GATCCGTTAA CCCACCAGTT GAAGCACCAC
 360
 CCAGGGCAGA TCGAAGCCGC GGCCGTCATG GAGTTCCTCC TCGACGGTAG CGACTACGTG
 420
 AAAGAAGCAG CGCGGCTTCA CGAGAAAGAC CCGTTGAGCA AACCGAAACA AGACCGCTAC
 480
 GCTCTGCGAA CATCGCCACA GTGGTTGGGG CCTCCGATCG AAGTCATCCG CGCTGCTACT
 540
 CACTCCATCG AGCGGGAGAT CAATTCCGTC AACGACAATC CGTTAATCGA TGTCTCCAGG
 600
 GACATGGCTC TCCACGGCGG CAACTTCCAG GGAACACCCA TCGGAGTTTC CATGGACAAC
 660
 ATGCGAATCT CTTTGGCAGC CGTC
 684

(2) INFORMATION FOR SEQ ID NO:46:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 418 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:46:

GAATTCGGCA CGAGGACAAG GTCATAGGCC CTCTCTTCAA ATGCTTGGAT GGGTGGAAAG
 60
 GAATCCTGG CCCATTCTGA AATAAATAAT CTTCCAAGAT CGCCTTTATA CAACGACTGC
 120
 TATGATTGA GTCCTCGGAT CTTTTTGTG ATGCAGTTGT TTACCGATCT GGAATTTGAT
 180
 TGGTCATAAA GCTTGATTTT GTTTTCTTT CTTTGTTTT ATACTGCTGG ATTGTCATCC
 240
 CATTGGATTT GCCAGAAATA TGTAAGGGTG GCAGATCATT TGGGTGATCT GAAACATGTA
 300
 AAAGTGGCGG ATCATTGGG TAGCATGCAG ATCAGTTGGG TGATCGTGTA CTGCTTTCAC
 360

TATTACTTAC ATATTTAAAG ATCGGGAATA AAAACATGAT TTTAATTGAA AAAAAAA
418

(2) INFORMATION FOR SEQ ID NO:47:

(1) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 479 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:47:

GATATCCCAA CGACCGAAAA CCTGTATTTT CAGGGCGCCA TGGGGATCCG GAATTCGGCA
60
CGAGCAAGGA AGAAAATATG GTTGCAGCAG CAGAAATTAC GCAGGCCAAT GAAGTTCAAG
120
TTAAAAGCAC TGGGCTGTGC ACGGACTTCG GCTCCTCTGG CAGCGATCCA CTGAACTGGG
180
TTCGAGCAGC CAAGGCCATG GAAGGAAGTC ACTTTGAAGA AGTGAAAGCG ATGGTGGATT
240
CGTATTTGGG AGCCAAGGAG ATTTCCATTG AAGGGAAATC TCTGACAATC TCAGACGTTG
300
CTGCCGTTGC TCGAAGATCG CAAGTGAAAG TGAAATTGGA TCGTCGGGCT GCCAAATCTA
360
GGGTCGAGGA GAGTTCAAAC TGGGTTCCTCA CCCAGATGAC CAAGGGGACG GATACCTATG
420
GTGTCACTAC TGGTTTCGGA GCCACTTCTC ACAGGAGAAC GAACCAGGGA GCCGAGCTT
479

(2) INFORMATION FOR SEQ ID NO:48:

(1) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 1785 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:48:

TATCGATAAG CTTGATATCG AATTCCTGCA GCCCGGGGGA TCCACTAGTT CTAGAGCGGC
60
CGCCACCGCG GTGGAGCTCG CGCGCCTGCA GGTCGACACT AGTGGATCCA AAGAATTCGG
120
CAGGAGGTTG CAGGTCGGGG ATGATTTGAA TCACAGAAAC CTCAGCGATT TTGCCAAGAA
180
ATATGGCAAA ATCTTTCTGC TCAAGATGGG CCAGAGGAAT CTTGTGGTAG TTTCACTCTC
240
CGATCTCGCC AAGGAGGTCC TGCACACCCA GGGCGTCGAG TTTGGGTCTC GAACCCGGAA
300
CGTGGTGTTT GATATCTTCA CGGGCAAGGG GCAGGACATG GTGTTACCG TCTATGGAGA
360
TCACTGGAGA AAGATGCGCA GGATCATGAC TGTGCCTTTC TTTACGAATA AAGTTGTCCA
420
GCACTACAGA TTCGCGTGGG AAGACGAGAT CAGCCGCGTG GTCGCGGATG TGAAATCCCC
480
CGCCGAGTCT TCCACCTCGG GCATTGTCAT CCGTAGGCGC CTCCAGCTCA TGATGTATAA
540
TATTATGTAT AGGATGATGT TCGACAGGAG ATTCGAATCC GAGGACGACC CGCTTTTCCT
600
CAAGCTCAAG GCCCTCAACG GAGAGCGAAG TCGATTGGCC CAGAGCTTTG AGTACAATTA
660
TGGGGATTTC ATTCCCATTC TTAGGCCCTT CCTCAGAGGT TATCTCAGAA TCTGCAATGA
720

GATTAAAGAG AAACGGCTCT CTCTTTTCAA GGACTACTTC GTGGAAGAGC GCAAGAAGCT
 780
 CAACAGTACC AAGACTAGTA CCAACACCGG GGGAGCTCAA GTGTGCAATG SACCATATTT
 840
 TAGATGCTCA GGACAAGGGA GAGATCAATG AGGATAATGT TTTGTACATC GTTGAGAACA
 900
 TCAACGTTGC AGCAATTGAG ACAACGCTGT GGTGATGGA ATGGGGAATA GTGGAGCTGG
 960
 TGAACCACCA GGACATTCAG AGCAAGGTGC GCGCAGAGCT GGACGCTGTT TTTGGACCAG
 1020
 GCGTGCAGAT AACGGAACCA GACACGACAA GGTTGCCCTA CCTTCAGGCG GTTGTGAAGG
 1080
 AAACCCTTCG TCTCCGCATG GCGATCCCGT TGCTCGTCCC CCACATGAAT CTCACGACG
 1140
 CCAAGCTCGG GGGCTACGAT ATTCCGGCAG AGAGCAAGAT CCTGGTGAAC GCCTGGTGGT
 1200
 TGGCCAACAA CCCCCCAAC TGAAGAACC CCGAGGAGTT CCGCCCCGAG CGTTTCTTCG
 1260
 AGGAGGAGAA GCACACCGAA GCAATGGCA ACGACTTCAA ATTCCTGCCT TGGTGTGGG
 1320
 GAGGAGGAGC TGCCCGGGAA TCATTCTGGC GCTGCCTCTC CTCGCACTCT CCATCGGAAG
 1380
 ACTTGTTTCA AACTTCCACC TTCTGCCGCC GCCCGGGCAG AGCAAAGTGG ATGTCACTGA
 1440
 GAAGGGCGGG CAGTTCAGCC TTCACATTCT CAACCATTCT CTCATGCTCG CCAAGCCCAT
 1500
 AGCTTCTGCT TAATCCCAAC TTGTCACTGA CTGGTATATA AATGCGCGCA CCTGAACAAA
 1560
 AAACACTCCA TCTATCATGA CTGTGTGTGC GTGTCCACTG TCGAGTCTAC TAAGAGCTCA
 1620
 TAGCACTTCA AAAGTTTGCT AGGATTTCAA TAACAGACAC CGTCAATTAT CTCATGTTTC
 1680
 AATAAAAGTT TGCATAAATT AAATGATATT TCAATATACT ATTTTGACTC TCCACCAATT
 1740
 GGGGAATTTT ACTGCTAAAA AAAAAAAAAA AAAAAAAAAA AAAAA
 1785

(2) INFORMATION FOR SEQ ID NO:49:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 475 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:49:

GAATTCGGCA CGAGATTTCC ATGGACGATT CCGTTTGGCT TCAATTCGTT TCCTCTGGCT
 60
 GTCCTCGTCC TCGTTTTCTT TGTTCTTCTT CCGACTTTTT CTCTGGAAGC TATGGCGTAA
 120
 TAGGAACCTG CCGCCAGGAC CCGCGCATG GCGATCGTA GGAACGTCC TTCAGATTGG
 180
 ATTTTCCAGC GGCGCGTTCT AGACCTCAGT GAAGAAATTC CATGAGAGAT ACGGTCCAAT
 240
 ATTCACTGTG TGGCTCGGTT CCGCCCTCTT GCTGATGATC ACCGACCGCG AGCTTGCCCA
 300
 CGAGGCGCTC GTACAGAAGG GCTCCGTCTT CGCTGACCGC CCGCCCGCCC TCGGGATGCA
 360
 GAAATCTTTC AGTAGCAACC AGCACAACAT CACTTCGGCT GAATACGGCC CGCTGTGGCG
 420
 GAGCCTTCGC AGGAATCTCG TTAAAGAAGC CCTGAGACTT CGGCGATGAA GGCTT
 475

(2) INFORMATION FOR SEQ ID NO:50:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 801 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:50:

GCTCCACCGA CGGTGGACGG TCCGCTACTC AGTAACTGAG TGGGATCCCC CGGGCTGACA
 60
 GGCAATTCGA TTTAGCTCAC TCATTAGGCA CCCCAGGCTT TACACTTTAT GCTTCCGGCT
 120
 CGTATGTTGT GTGGAATTGT GAGCGGATAA CAATTTTACA CAGGAAACAG CTATGACCAT
 180
 GATTACGCCA AGCGCGCAAT TAACCCTCAC TAAAGGGAAC AAAAGCTGGA GCTCCACCGC
 240
 GGTGGCGGCC GCTCTAGAAC TAGTGGATCC AAAGAATTCG GCACGAGACC CAGTGACCTT
 300
 CAGGCCTGAG AGATTTCTTG AGGAAGATGT TGATATTAAG GGCCATGATT ACAGGCTACT
 360
 GCCATTCGGT GCAGGGCGCA GGATCTGCCC TGGTGACAA TTGGGTATTA ATTTAGTTCA
 420
 GTCTATGTTG GGACACCTGC TTCATCATTT CGTATGGGCA CCTCCTGAGG GAATGAAGGC
 480
 AGAAGACATA GATCTCACAG AGAATCCAGG GCTTGTTACT TTCATGGCCA AGCCTGTGCA
 540
 GGCCATTGCT ATTCCTCGAT TGCCTGATCA TCTCTACAAG CGACAGCCAC TCAATTGATC
 600
 AATTGATCTG ATAGTAAGTT TGAATTTTGT TTTGATACAA AACGAAATAA CGTGCAGTTT
 660
 CTCCTTTTCC ATAGTCAACA TGCAGCTTTC TTTCTCTGAA GCGCATGCAG CTTTCTTTCT
 720
 CTGAAGCCCA ACTTCTAGCA AGCAATAACT GTATATTTTA GAACAAATAC CTATTCCTCA
 780
 AATTGAGTAT TTCTCTGTAG G
 801

(2) INFORMATION FOR SEQ ID NO:51:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 744 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:51:

GGGCCCCCCT TCGAGGTGGA CACTAGTGGA TCCAAAGAAT TCGGCACGAG GTTTTATCTG
 60
 AAGGACGCTG TGCTTGAAGG CTCCCAGCCA TTCACCAAAG CCCATGGAAT GAATGCGTTC
 120
 GAGTACCCGG CCATCGATCA GAGATTCAAC AAGATTTTCA ACAGGGCTAT GTCTGAGAAT
 180
 TCTACCATGT TGATGAACAA GATTTTGGAT ACTTACGAGG GTTTTAAGGA GGTTCAGGAG
 240
 TTGGTGGATG TGGGAGGAGG TATTGGGTCG ACTCTCAATC TCATAGTGTC TAGGTATCCC
 300
 CACATTTTCA GAATCAACTT CGACTTGTCC CATGTGCTGG CCGATGCTCC TCACTACCCA
 360
 GCTGTGAAAC ATGTGGGTGG AGACATGTTT GATAGTGATC CAAGTGGCCA AGCTATTTTT
 420
 ATGAAGTGGG TTCTGCATGA TTGGAGCGAT GATCATTGCA GGAAGCTTTT GAAGAATTGT
 480

AGCCCTTGCA TTGCCCGATG ATGGAAAGAT TCTAGCCATG GACATCAACA GAGAGAACTA
 540
 TGATATCGGA TTGCCTATAA TT
 562

(2) INFORMATION FOR SEQ ID NO:54:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 1074 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:54:

TCGTGCCGCT CGATCCTCAC AGGCCCTTTT TATTTCCCTG GTGAACGATA CGATGGGCTC
 60
 GCACGCTGAG AATGGCAACG GGGTGGAGGT TGTTGATCCA ACGGACTTAA CTGACATCGA
 120
 GAATGGGAAA CCAGGTTATG ACAAGCGTAC GCTGCCTGCG GACTGGAAGT TTGGAGTGAA
 180
 GCTTCAAAA C GTTATGGAAG AATCCATTTA CAAGTACATG CTGGAAACAT TCACCCGCCA
 240
 TCGAGAGGAC GAGGCGTCCA AGGAGCTCTG GGAACGAACA TGGAACCTGA CACAGAGAGG
 300
 GGAGATGATG ACATTGCCAG ATCAGGTGCA GTTCCTGCGC TTGATGGTAA AGATGTCAGG
 360
 TGCTAAAAAG GCATTGGAGA TCGGAGTTTT CACTGGCTAT TCATTGCTCA ATATCGCTCT
 420
 CGCTCTTCCT TCTGATGGCA AGGTGGTAGC TGTGGATCCA GGAGATGACC CCAAATTTGG
 480
 CTGGCCCTGC TTCGTTAAGG CTGGAGTTGC AGACAAAGTG GAGATCAAGA AACTACAGG
 540
 GTTGGACTAT TTGGATTCCC TTATTCAAAA GGGGGAGAAG GATTGCTTCG ACTTTGCATT
 600
 CGTGGACGCA GACAAAGTGA ACTACGTGAA CTATCATCCA CGGCTGATGA AGTTAGTGCG
 660
 CGTGGGGGGG GTCATAATTT ACGACGACAC CCTCTGGTTT GGTCTGGTGG GAGGAAAGGA
 720
 TCCCCACAAC CTGCTTAAGA ATGATTACAT GAGGACTTCT CTGGAGGGTA TCAAGGCCAT
 780
 CAACTCCATG GTAGCCAACG ACCCCAACCTT GGAGGTCGCC ACAGTCTTTA TGGGATATGG
 840
 TGTCACTGTT TGTTACCGCA CTGCTTAGTT AGCTAGTCCT CCGTCATTCT GCTATGTATG
 900
 TATATGATAA TGGCGTCGAT TTCTGATATA GGTGGTTTTT CAATGTTTCT ATCGTCATGT
 960
 TTTCTGTTTA GCCAGAATGT TTCGATCGTC ATGGTTTCTG TTAAAGCCAG AATAAAATTA
 1020
 GCCGCTTGCA GTTCAAAAAA AAAAAAAAAA AAAAACTCGA GACTAGTTCT CTTC
 1074

(2) INFORMATION FOR SEQ ID NO:55:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 1075 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:55:

TCGGAGCTCT CGAATCCTCA CAGGCCCTTT TTATTTCCCT GGTGAACGAT ACGATGGGCT
 60

CACAAGGCGT TGCCAGAGAA GGGGAAGGTG ATTGCGGTGG ACACCATTCT CCCAGTGGCT
 540
 GCAGAGACAT CTCCTTATGC TCGTCAGGGA TTTCATACAG ATTTACTGAT GTTGGCATAAC
 600
 AACCAGGGG GCAAGGAACG CACAGAGCAA GAATTTCAAG ATTTAGCTAA GGAGACGGGA
 660
 TTTGCAGGTG GTGTTGAACC TGTATGTTGT GTCAATGGAA TGTGGGTAAT GGAATTCCTG
 720
 CAGCCCGGGG GATCCACTAG TTCT
 744

(2) INFORMATION FOR SEQ ID NO:52:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 426 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:52:

GTGGCCCTGG AAGTAGTGTG CGCGACATGG ATTCCTTGAA TTTGAACGAG TTTATGTTGT
 60
 GGTTCCTCTC TTGGCTTGCT CTCTACATTG GATTCGTTA TGTTTTGAGA TCGAACTTGA
 120
 AGCTCAAGAA GAGGCGCCTC CCGCCGGGCC CATCGGGATG GCCAGTGGTG GGAAGTCTGC
 180
 CATTGCTGGG AGCGATGCCT CACGTTACTC TCTACAACAT GTATAAGAAA TATGGCCCCG
 240
 TTGTCTATCT CAAACTGGGG ACGTCCGACA TGGTTGTGGC CTCCACGCCC GCTGCAGCTA
 300
 AGGCGTTTCT GAAGACTTTG GATATAAACT TCTCCAACCG GCCGGGAAAT GCAGGAGCCA
 360
 CGTACATCGC CTACGATTCT CAGGACATGG TGTGGGCAGC GTATGGAGGA CGGTGGAAGA
 420
 TGGAGC
 426

(2) INFORMATION FOR SEQ ID NO:53:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 562 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:53:

CAGTTCGAAA TTAACCTCAC TAAAGGGAAC AAAAGCTGGA GTTCGCGCGC CTGCAGGTCC
 60
 AACTAGTGG ATCCAAAGAA TTCGGCACGA GCTTTGAGGC AACCTACATT CATTGAATCC
 120
 CAGGATTTCT TCTTGTCCAA ACAGGTTTAA GGAAATGGCA GGCACAAGTG TTGCTGCAGC
 180
 AGAGGTGAAG GCTCAGACAA CCCAAGCAGA GGAGCCGGTT AAGGTTGTCC GCCATCAAGA
 240
 AGTGGGACAC AAAAGTCTTT TGCAGAGCGA TGCCCTCTAT CAGTATATAT TGGAAACGAG
 300
 CGTGTACCCT CGTGAGCCCG AGCCAATGAA GGAGCTCCGC GAAGTGACTG CCAAGCATCC
 360
 CTGGAACCTC ATGACTACTT CTGCCGATGA GGGTCAATT CTGGGCCTCC TGCTGAAGCT
 420
 CATTAACGCC AAGAACACCA TGGAGATTGG GGTGTACACT GGTACTCGC TTCTCAGCAC
 480

AAGCCGACGA AACCCAATGC CCGGCCGTGA CAATCCACCC GGACGATGTC GTGGCGTTGC
 660
 CCTATTCTTC CGGAACCACG GGGCTCCCCA AGGGCGTGAT GTTAACGCAC AAAGGCCTGG
 720
 TGTCCAGCGT TGCCCAGCAG GTCGATGGTG AAAATCCCAA TCTGTATTTT CATTCCGATG
 780
 ACGTGATACT CTGTGTCTTG CCTCTTTTCC ACATCTATTC TCTCAATTCC GTTCTCCTCT
 840
 GCGCGCTCAG AGCCGGGGCT GCGACCCCTGA TTATGCAGAA ATTCAACCTC ACGACCTGTC
 900
 TGGAGCTGAT TCAGAAATAC AAGGTTACCG TTGCCCCAAT TGTGCCTCCA ATTGTCTCTG
 960
 ACATCACAAA GAGCCCCATC GTTTCCAGT ACGATGTCTC GGCCGTCCGG ATAATCATGT
 1020
 CCGGCGCTGC GCCTCTCGGG AAGGAACTCG AAGATGCCCT CAGAGAGCGT TTTCCCAAGG
 1080
 CCATTTTCGG GCAGGGCTAC GGCATGACAG AAGCAGGCCC GGTGCTGGCA ATGAACCTAG
 1140
 CCTTCGCAAA GAATCCTTTC CCGGTCAAAT CTGGCTCCTG CCGAACAGTC GTCCGGAACG
 1200
 CTCAAATAAA GATCCTCGAT ACAGAACTG GCGAGTCTCT CCGGCACAAT CAAGCCGGCG
 1260
 AAATCTGCAT CCGCGGACCC GAAATAATGA AAGGATATAT TAACGACCCG GAATCCACGG
 1320
 CCGCTACAAT CGATGAAGAA GGCTGGCTCC ACACAGGCGA CGTCGGGTAC ATTGACGATG
 1380
 ACGAAGAAAT CTTCATAGTC GACAGAGTAA AGGAGATTAT CAAATATAAG GGCTTCCAGG
 1440
 TGGCTCCTGC TGAGCTGGAA GCTTTACTTG TTGCTCATCC GTCAATCGCT GACGCAGCAG
 1500
 TCGTTCCTCA AAAGCACGAG GAGGCGGGCG AGGTTCCGGT GGCGTTCGTG GTGAAGTCGT
 1560
 CGGAAATCAG CGAGCAGGAA ATCAAGGAAT TCGTGGCAAA GCAGGTGATT TTCTACAAGA
 1620
 AAATACACAG AGTTTACTTT GTGGATGCGA TTCCTAAGTC GCGGTCCGGC AAGATTCTGA
 1680
 GAAAGGATTT GAGAAGCAGA CTGCCAGCAA AATGAAAATG AATTTCCATA TGATTCTAAG
 1740
 ATTCCTTTGC CGATAATTAT AGGATTCCTT TCTGTTCACT TCTATTTATA TAATAAAGTG
 1800
 GTGCAGAGTA AGCGCCCTAT AAGGAGAGAG AGAGCTTATC AATTGTATCA TATGGATTGT
 1860
 CAACGCCCTA CACTCTTGCG ATCGCTTTCA ATATGCATAT TACTATAAAC GATATATGTT
 1920
 TTTTATTATAA ATTTACTGCA CTTCTCGTTC AAAAAAAAAA A
 1961

(2) INFORMATION FOR SEQ ID NO:57:

(1) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 1010 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(1) SEQUENCE DESCRIPTION: SEQ ID NO:57:

GACAACTTG GTCGTTTGTT TAGGTTTTCG TGCAGGTGAA CACTAATATG GAAGGCCAGA
 60
 TTGCAGCATT AAGCAAAGAA GATGAGTTCA TTTTTCACAG CCTTTTCTCT SCAGTACCTG
 120
 TTCCAGAGAA TATAAGTCTT TTCCAGTTTG TTCTGGAAGG TGCTGAGAAA TACCGTGATA
 180
 AGGTGGCCCT CGTGGAGGCC TCCACAGGGA AGGAGTACAA CTATGGTCAG GTGATTTCCG
 240

CGCACGCTGA GAATGGCAAC GGGGTGGAGG TTGTTGATCC AACGGACTTA ACTGACATCG
 120
 AAGAATGGGA AACCAGGTTA TGACAAGCST CGCTGCCTGC GGAAGTGAAG TTTGGAGTGA
 180
 AGCTTCAAAA CGTTATGGAA GAATCCATTT ACAAGTACAT GCTGGAAACA TTCACCCGCC
 240
 ATCGAGAGGA CGAGGCGTCC AAGGAGCTCT GGGAAACGAAC ATGGAACCTG ACACAGAGAG
 300
 GGGAGATGAT GACATTGCCA GATCAGGTGC AGTTCTGCG CTTGATGGTA AAGATGTCAG
 360
 GTGCTAAAAA GGCATTGGAG ATCGGAGTTT TCACTGGCTA TTCATTGCTC AATATCGCTC
 420
 TCGCTCTTCC TTCTGATGGC AAGGTGGTAG CTGTGGATCC AGGAGATGAC CCCAAATTTG
 480
 GCTGGCCCTG CTTGTTAAG GCTGGAGTTG CAGACAAAGT GGAGATCAAG AAAACTACAG
 540
 GGTGGACTA TTTGGATTCC CTTATTCAA AGGGGGAGAA GGATTGCTTC GACTTTGCAT
 600
 TCGTGGACGC AGACAAAGTG AACTACGTGA ACTATCATCC ACGGCTGATG AAGTTAGTGC
 660
 GCGTGGGGGG CGTCATAATT TACGACGACA CCCTCTGGTT TGGTCTGGTG GGAGGAAAGG
 720
 ATCCCCACAA CCTGCTTAAG AATGATTACA TGAGGACTTC TCTGGAGGGT ATCAAGGCCA
 780
 TCAACTCCAT GGTAGCCAAC GACCCCACT TGGAGGTCCG CACAGTCTTT ATGGGATATG
 840
 GTGTCACTGT TTGTTACCGC ACTGCTTAGT TAGCTAGTCC TCCGTCATTC TGCTATGTAT
 900
 GTATATGATA ATGGCGTCGA TTTCTGATAT AGGTGGTTTT TCAATGTTTC TATCGTCATG
 960
 TTTTCTGTTT AGCCAGAATG TTTGATCGT CATGGTTTCT GTTAAAGCCA GAATAAAATT
 1020
 AGCCGCTTGC AGTTCAAAAA AAAAAAAAAA AAAAAACTCG AGACTAGTTC TCTTC
 1075

(2) INFORMATION FOR SEQ ID NO:56:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 1961 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:56:

GTTTTCCGCC ATTTTTCGCC TGTTCCTGCG GAGAATTGA TCAGGTTCCG ATTGGGATTG
 60
 AATCAATTGA AAGGTTTTTA TTTTCAGTAT TTCGATCGCC ATGGCCAACG GAATCAAGAA
 120
 GGTGAGCAT CTGTACAGAT CGAAGCTTCC CGATATCGAG ATCTCCGACC ATCTGCCTCT
 180
 TCATTGCTAT TGCTTTGAGA GAGTAGCGGA ATTGCGAGAC AGACCCTGTC TGATCGATGG
 240
 GGCGACAGAC AGAAGTTATT GCTTTTCAGA GGTGGAAGT ATTTCTCGCA AGGTGCGTGC
 300
 CGGTCTGGCG AAGCTCGGGT TGCAGCAGGG GCAGGTTGTC ATGCTTCTCC TTCCGAATTG
 360
 CATCGAATTT GCGTTTGTGT TCATGGGSGC CTCTGTCCGG GGCGCCATTG TGACCACGGC
 420
 CAATCCTTTC TACAAGCCGG GCGAGATCGC CAAACAGGCC AAGGCCGCGG GCGCGCGCGA
 480
 TCATAGTTAC CCTGGCAGCT TATGTGGAGA AACTGGCCGA TCTGCAGAGC CACGATGTGC
 540
 TCGTCATCAC AATCGATGAT GCTCCCAAGG AAGGTTGCCA ACATATTTCC GTTCTGACCG
 600

TCACAAGGAA TGTTGCAGCT GGGCTCGTGG ACAAAGGCAT TCAAAGGGC GATGTTGTAT
 300
 TTGTTCTGCT TCCAAATATG GCAGAATACC CCATTATTGT GCTGGGAATA ATGTTGGCCG
 360
 GCGCAGTGTT TTCTGGGGCA AATCCTTCTG CACACATCAA TGAAGTTGAA AAACATATCC
 420
 AGGATTCTGG AGCAAAGATT GTTGTGACAG TTGGGTCTGC TTATGAGAAG GTGAGGCAAG
 480
 TGAAACTGCC TGTTATTATT GCAGATAACG AGCATGTCAT GAACACAATT CCATTGCAGG
 540
 AAATTTTGA GAGAACTAT GAGGCCGAG GGCCTTTTGT ACAAATTTGT CAGGATGATC
 600
 TGTGTGCACT CCCTTATTCC TCTGGCACCA CAGGGGCCTC TAAAGGTGTC ATGCTCACTC
 660
 ACAGAAATCT GATTGCAAAT CTGTGCTCTA GCTTGTTTGA TGTCCATGAA TCTCTTGTAG
 720
 GAAATTTTAC CACGTTGGGG CTGATGCCAT TCTTTCACAT ATATGGCATC ACGGGCATCT
 780
 GTTTCGCCAC TCTTCGCAAC GGAGGCAAGG TCGTGGTCAT GTCCAGATTC GATCTCCGAC
 840
 ACTTTATCAG TTCTTTGATT ACTTATGAGG TCAACTTCGC GCCTATTGTC CCGCCTATAA
 900
 TCGTCTCCCT CCGGTTTAAA AATCCTATCG TTAACGAGTT CGATCTCAGC CGCTTGAAAC
 960
 TCCAAAGCTG TTCATGACTG CGGCTGCTCC ACTGGCGCCG GATCTACTGC
 1010

(2) INFORMATION FOR SEQ ID NO:58:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 741 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:58:

GAATTCGGCA CGAGACCATT TCCAGCTAAT ATTGGCATAG CAATTGGTCA TTCTATCTTT
 60
 GTCAAAGGAG ATCAAACAAA TTTTGAAATT GGACCTAATG GTGTGGAGGC TAGTCAGCTA
 120
 TACCCAGATG TGAAATATAC CACTGTGGAT GAGTACCTCA GCAAATTTGT GTGAAGTATG
 180
 CGAGATTCTC TTCCACATGC TTCAGAGATA CATAACAGTT TCAATCAATG TTTGTCCTAG
 240
 GCATTTGCCA AATTGTGGGT TATAATCCTT CGTAGGTGTT TGGCAGAACA GAACCTCCTG
 300
 TTTAGTATAG TATGACGAGC TAGGCACTGC AGATCCTTCA CACTTTTCTC TTCCATAAGA
 360
 AACAAATACT CACCTGTGGT TTGTTTTCTT TCTTTCTGGA ACTTTGGTAT GGCAATAATG
 420
 TCTTTGGAAA CCGCTTAGTG TGGAATGCTA AGTACTAGTG TCCAGAGTTC TAAGGGAGTT
 480
 CCAAATCAT GGCTGATGTG AACTGTTGT TCCAGAGGGT GTTTACAACC AACAGTTGTT
 540
 CAGTGAATAA TTTTGTTAGA GTGTTTAGAT CCATCTTTAC AAGGCTATTG AGTAAGGTTG
 600
 GTGTTAGTGA ACGGAATGAT GTCAAATCTT GATGGGCTGA CTGACTCTCT TGTGATGTCA
 660
 AATCTTGATG GATTGTGTCT TTTTCAATGG TAAAAA AAAA AAAAAA
 720
 AAAAAA AAAAAA A
 741

(2) INFORMATION FOR SEQ ID NO:59:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 643 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:59:

CTCATCTCGG AGTTGCAGGC TGCAGCTTTT GGCCCAAAGC ATGATATCAG ATCAAACGAC
60
GCAGATGAAG CAAACGGATC AAACAGTTTG CGTTACTGGA GCAGCGGGTT TCATTGCCTC
120
ATGGCTTGTC AAGATGCTCC TCATCAGAGG TTACACTGTC AGAGCAGCAG TTCGGACCAA
180
CCCAGCTGAT GATAGGTGGA AGTATGAGCA TCTGCGAGAG TTGGAAGGAG CAAAAGAGAG
240
GCTTGAGCTT GTGAAAGCTG ATATTCTCCA TTACCAGAGC TTACTCACAG TCATCAGAGG
300
TTGCCACGGT GTCTTTCACA TGGCTTCAGT TCTCAATGAT GACCCGTGAGC AAGTGATAGA
360
ACCAGCAGTC GAAGGGACGA GGAATGTGAT GGAGGCCTGC GCAGAAACTG GGGTGAAGCG
420
CGTTGTTTTT ACTTCTTCCA TCGGCGCAGT TTACATGAAT CCTCATAGAG ACCCGCTCGC
480
GATTGTCCAT GATGACTGCT GGAGCGATTT GACTACTGCG TACAAACCAA GAATTGGTAT
540
TGCTATGCAA AAACCTTGGC AGAGAAATCT GCATGGGATA TTGCTAAGGG AAGGAATTTA
600
GAGCTTGCAG TGATAAATCC AGGCCTGGCC TTAGGTCCCT TGA
643

(2) INFORMATION FOR SEQ ID NO:60:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 441 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:60:

GAATTCCGCA CGAGAATTTT TCTGTGGTAA GCATATCTAT GGCTCAAACC AGAGAGAAGG
60
ACGATGTCAG CATAACAAAC TCCAAAGGAT TGGTATGCGT GACAGGAGCG GCTGGTTACT
120
TGGCATCTTG GCTTATCAAG CGTCTCCTCC AGTGTGGTTA CCAAGTGAGA GGAAGTGTGC
180
GGGATCCTGG CAATGAGAAA AAGATGGCTC ATTTATGGAA GTTAGATGGG GCGAAAGAGA
240
GACTGCAACT AATGAAAGCT GATTTAATGG ACGAGGGCAG CTTGATGAG GTCATCAGAG
300
GCTGCCATGG TGTTTTTCAC ACAGCGTCTC CAGTCGTGGG TGTCAAATCA GATCCCAAGA
360
TATGGTATGC TCTGGCCAAG ACTTTAGCAG AAAAAGCAGC ATGGGATTTT GCCCAAGAAA
420
ACCATCTGGA CATGGTTGCA G
441

(2) INFORMATION FOR SEQ ID NO:61:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 913 base pairs
- (B) TYPE: nucleic acid

(C) STRANDEDNESS: single
(D) TOPOLOGY: linear

(x1) SEQUENCE DESCRIPTION: SEQ ID NO:61:

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GAATTCGGCA CGAGGAAAAC ATCATCCAGG CATTTTGGAA ATTTAGCTCG CCGGTTGATT
60
CAGGATCCTG CAATGGCTTT TGGCGAAGAG CAGACTGCCT TGCCACAAGA AACGCCTTTG
120
AATCCTCCCG TCCATCGAGG AACAGTGTGC GTTACAGGAG CTGCTGGGTT CATAGGGTCA
180
TGGCTCATCA TCGGATTGCT TGAGCGAGGA TATAGTGTTA GAGCAACTGT GCGAGACACT
240
GGTAATCCTG TAAAGACAAA GCATCTGTTG GATCTGCCGG GGGCAAATGA GAGATTGACT
300
CTCTGGAAA GAGATTGGGA TGATGAAGGA AGCTTTGATG CTGCCATTGA TGGGTGTGAG
360
GGTGTTTTCC ATGTTCCAC TCCCATGGAT TTCGAGTCCG AGGATCCCGA GAATGAGATA
420
ATTAAGCCAA CAATCAACGG GGTCTTGAAT GTTATGAGAT CGTGTGCAAA AGCCAAGTCC
480
GTGAAGCGAG TTGTTTTCAC GTCATCTGCT GGGACTGTGA ATTTTACAGA TGATTTCCAA
540
ACACCAGGCA AAGTTTTTGA CGAATCATGC TGGACCAACG TGGATCTTTG CAGAAAAGTT
600
AAAATGACAG GATGGATGTA CTTTGTATCG AAGACATTAG CAGAGAAAGC TGCTTGGGAT
660
TTTGCAAGG AGAACAAGAT CGATCTCATT ACTGTTATCC CCACATTGGT CGTTGGACCA
720
TTCATTATGC AGACCATGCC ACCGAGCATG ATCAGAGCCT TGGCACTGTT AACGCGGAAT
780
GAACCCCACT ACATGATACT GAGACAGGTA CAGCTGGTTC ACTTGGATGA TCTCTGATG
840
TCACATATCT TTGTATATGA ACATCCTGAA GCAAAGGGCA GATACATCTC TTCCACATGT
900
GATGCTACCC ATT
913

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(2) INFORMATION FOR SEQ ID NO:62:

(1) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 680 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: single
(D) TOPOLOGY: linear

(x1) SEQUENCE DESCRIPTION: SEQ ID NO:62:

```

GAATTCGGCA CGAGATCAAT TTTTGCATAT TATTA AAAAG TAAGTGATT CGTTCTCTAT
60
ATTGATCAGT CACAGAGTCA TGGCCAGTTG TGGTTCCGAG AAAGTAAGAG GGTGGAATGG
120
AGATGAAGCA TGCGAAGAGA ACAAGAGAGT GGTTTGTGTA ACTGGGGCAA ATGGGTACAT
180
CGGCTCTTGG CTGGTCATGA GATTACTGGA ACATGGCTAT TATGTTTATG GAACTGTTAG
240
GGACCCAGAA GACACAGGGA AGGTTGGGCA TTTGCTGCCG CTCCCAGGGG CAAGTGAGAA
300
GCTAAAGCTG TTCAAGGCAG AGCTTAACGA CGAAATGCC TTTGATGATG CTGTGAGCGG
360
TTGTCAAGGG GTTTTCCACG TTGCCAAGCC TGTTAATCTG GACTCAAACG CTCTTCAGGG
420
GGAGGTTGTT GGTCCTGCCG TGAGGGGAAC AGTAAATCTG CTTCGAGCCT GCGAACGATC
480

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GGGCACTGTS AAACGASTGA TACATACCTC GTCCGTTTCA GCAGTGAGAT TCACTGGGAA
 540
 ACCTGACCCG CCTGATACTG TGCTGGATGA ATCTCATTGG ACTTCGGTGG AGTATTGCAG
 600
 AAAGACAAAG ATGGTCGGAT GGATGTACTA CATGCCCAAC ACTTATGCAG AAGAGGGAGC
 660
 CCATAAGTTC GGATCAGAGA
 680

(2) INFORMATION FOR SEQ ID NO:63:

(1) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 492 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(x1) SEQUENCE DESCRIPTION: SEQ ID NO:63:

GAATTCGGCA CGAGGCTGGT TCAAGTGTCA GCGCAATGGC GTCCCTTACA GAGAATCCCC
 60
 AGATTTGAGA AGAGCTGCTA AATCATGAGA TCCATCAAGG AAGTACAGTA TGTGTGACAG
 120
 GAGCTGCTGG CTTCATAGGA TCATGGCTCG TCATGCGTTT GCTTGAGCGA GCATATACTG
 180
 TTAGAGGAAC TGTGCGAGAC ACTGGTAATC CGGTGAAGAC GAAGCATCTA TTGGATCTGC
 240
 CTGGGGCGAA TGAGAGGTTA ACTCTCTGGA AAGCAGATTT GGATGATGAA GGAAGCTTTG
 300
 ACGCCGCCAT TGATGGTTGT GAGGGAGTTT TCCATGTTGC CACTCCCATG GATTTTGAAT
 360
 CCGAGGACCC CGAGAACGAG ATAATTAAAC CCGCTGTCAA TGGGATGTTG AATGTTTGA
 420
 GATCGTGTGG GAAACCAAG TCTATGAAGC GAGTTGTTTT CACGTCGTCT GCTGGGACTC
 480
 TGCTTTTAC GG
 492

(2) INFORMATION FOR SEQ ID NO:64:

(1) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 524 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(x1) SEQUENCE DESCRIPTION: SEQ ID NO:64:

GAATTCGGCA CGAGCTTGTT CAAAGTCACA TATCTTATTT TCTTTGTGAT ATCTGCAATT
 60
 TCCAAGCTTT TCGTCTACCT CCCTGAAAAG ATGAGCGAGG TATGCGTGAC AGGAGGCACA
 120
 GGCTTCATAG CTGCTTATCT CATTCGTAGT CTTCTCCAGA AAGGTTACAG AGTTCGCACT
 180
 ACAGTTCGCA ACCCAGATAA TGTGGAGAAG TTTAGTTATC TGTGGGATCT GCCTGGTGCA
 240
 AACGAAAGAC TCAACATCCT GAGAGCAGAT TTGCTAGAGG AAGGCAGTTT TGATGCAGCA
 300
 GTAGATGGTS TAGATGGAGT ATTCCATACT GCATCACCTG TCTTAGTCCC ATATAACGAG
 360
 CGCTTGAAGG AAACCCTAAT AGATCCTTGT GTGAAGGGCA CTATCAATGT CCTCAGGTCC
 420
 TGTTCAGAT CACCTTCAGT AAAGCGGGTG GTGCTTACAT CCTCCTGCTC ATCAATACCG
 480

ATACGACTAT AATAGCTTAG AGCGTTCCCT GCTGGACTGA GTCA
524

(2) INFORMATION FOR SEQ ID NO:65:

(1) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 417 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(x1) SEQUENCE DESCRIPTION: SEQ ID NO:65:

TCCTAATTGT TCGATCCTCC CTTTTAAAGC CTTTCCCTGG CCTTCATTCC AGGTCACAGA
60
GTTGTTTCATG CAGTGCTAGC AGGAGGAGCA GCGTTGCAAT TGGGGAAAAT TCCAAAATCA
120
ATAACGAGAG GACAGAAGTA AGTTTGTGGA AATAGCAACC ATGCCGGTGT TTCCTTCTGG
180
TCTGGACCCC TCTGAGGACA ATGGCAAGCT CGTTTGTGTC ATGGATGCGT CCAGTTATGT
240
AGGTTTGTGG ATTGTTCAGG GCCTTCTTCA ACGAGGCTAT TCAGTGCATG CCACGGTSCA
300
GAGAGACGCT GCGGAGGTTG AGTCTCTCAG AAAATTGCAT GGGGATCGAT TSCAGATCTT
360
CTATGCAGAT GTCTTGGATT ATCACAGCAT TACTGATGCG CTCGAGGGCT GTTCTGG
417

(2) INFORMATION FOR SEQ ID NO:66:

(1) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 511 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(x1) SEQUENCE DESCRIPTION: SEQ ID NO:66:

ATGACACGAA TTTGTGCCTC TCTCTGACCA GAGCTTGAAG CTCTGTCTTC TCTGATATCG
60
CTTCATTCCA TCATCCAGGA GCTTCTGTTA TATCCATTTC CTCGAAATGS ATGCCATCCT
120
TGAAGAAAAT GGATACGGCG CTTCCAATTC TCGGAAATTA ATGTGCCTTA CCGGGGGCTG
180
GAGTTTCCTG GGGATTCATA TCGCAAGAAT GCTGCTCGGC CGGGGTTACT CAGTCCSTTT
240
CGCAATTCCG GTAACGCCAG AAGAGGCAGG CTCACTTATG GAATCCGAAG AAGCATTATC
300
GGGGAAGCTG GAGATATGCC AAGCCGATCT CTTGGATTAT CGCAGCGTTT TCGGCAACAT
360
CAATGGTTGC TCCGGAGTCT TCCACGTCCC TCGGCCCTGT GATCATCTGG ATGGATTACA
420
GGAGTATCCG GTATGATTAG TTTAATAGAT TGACGGGGTA TCCTGTATGA ATTAGTTTAT
480
GAATTTAAGG TTTTCTTAGA ATTTGGATAC T
511

(2) INFORMATION FOR SEQ ID NO:67:

(1) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 609 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(X1) SEQUENCE DESCRIPTION: SEQ ID NO:67:

CATTGATAGT TGATGGAAGA CCATCAGTAA AGCATGAAAA AGAAATTGTT CCAAGGTGAA
 60
 GAAGTCAGTT GCTCCAGCAG AACCTTTTAA GCAATTGTTT TTSTATCCTT TTTGCCTTTG
 120
 AATATGTAAT CCATAAACTT ATGCAGGAAG TGCCTCGTGC CGAATTCGGC ACGAGAATCA
 180
 CTGACCTTCA CATATTTATT CCAATTCTAA TATCTCTACT CGCTGTCTAG CTGATTTTTG
 240
 AGTGGCGAAG CAACTTGACA GGGTTGGACA TGGCCAACAG CAGCAAGATT CTGATTATTG
 300
 GAGGAACAGG CTACATTGGT CSTCATATAA CCAAAGCCAG CCTTGCTCTT GGTATCCCA
 360
 CATTCCCTCT TGTCAGAGAG ACCTCCGCTT CTAATCCTGA GAAGGCTAAG CTTCTGGAAT
 420
 CCTTCAAGGC CTCAGGTGCT ATTATACTCC ATGGATCTTT GGAGGACCAT CCAAGTCTTG
 480
 TGGAGGCAAT CAAGAAAGTT GATGTAGTTA TCTCGGCTGT CAAGGGACCA CAGCTGACGG
 540
 TTCAAACAGG ATATTTATCC AGGGTATTTA AAGGGAGGCT TGAACCCAT CAAGAAGGGT
 600
 TTTGGCCAA
 609

(2) INFORMATION FOR SEQ ID NO:68:

(1) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 474 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(X1) SEQUENCE DESCRIPTION: SEQ ID NO:68:

GCAAGATAGG TTTTATTCTT CTGGAGTTGG GTGAGGCTTG GAAATTTAAG TAAAAAGGGT
 60
 GCATAGCAAT TAAGCAGTTG CAGCCATGGC GGTCTGTGGA ACTGAAGTAG CTCATACTGT
 120
 GCTCTATGTA GCTGCAGACA TGGTGGAAAA CAACACGTCT ATTGTGACCA CCTCTATGGC
 180
 TGCAGCAAAT TGTGAGATGG AGAAGCCTCT TCTAAATTCC TCTGCCACCT CAAGAATACT
 240
 GGTGATGGGA GCCACAGGTT ACATTGGCCG TTTTGTGTCG CAAGAAGCTG TTGCTGCTGG
 300
 TCATCCTACC TATGCTCTTA TAGGCCCGTT TGCTGCTTGT GACCTGGCCA AAGCACAGCG
 360
 CGTCCAACAA TTGAAGGATG CCGGGGTCCA TATCCTTTAT GGGTCTTTGA GTGATCACAA
 420
 CCTCTTAGTA AATACATTGA AGGACATGGG CCGTTGTTAT CTCTACCATT GGAG
 474

(2) INFORMATION FOR SEQ ID NO:69:

(1) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 474 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(X1) SEQUENCE DESCRIPTION: SEQ ID NO:69:

GCAAGATAGG TTTTATTCTT CTGGAGTTGG GTGAGGCTTG GAAATTTAAG TAAAAAGGGT
60
GCATAGCAAT TAAGCAGTTG CAGCCATGGG GGTCTGTGGA ACTGAAGTAG CTCATACTGT
120
GCTCTATGTA GCTGCAGACA TGGTGGAAAA CAACAGCTCT ATTGTGACCA CCTCTATGGC
180
TGCAGCAAT TGTGAGATGG AGAAGCCTCT TCTAAATCC TGTGGCACCT CAAGAATACT
240
GGTGATGGGA GCCACAGGTT ACATTGGCCG TTTTGTGGC CAAGAAGCTG TTGCTGCTGG
300
TCATCCTACC TATGCTCTTA TACGCCCTT TGCTGCTGT GACCTGGCCA AAGCACAGCG
360
CGTCCACAA TTGAAGGATG CCGGGGTCCA TATCCTTTAT GGGTCTTTGA GTGATCACA
420
CCTCTTAGTA AATACATTGA AGGACATGGG CCCTTCTTAT CTCTACCATT GGAG
474

(2) INFORMATION FOR SEQ ID NO:70:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 608 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:70:

CATTGATAGT TGATGGAAGA CCATCAGTAA AGCATGAAAA AGAAATTGTT CCAAGGTGAA
60
GAAGTCAGTT GCTCCAGCAG AACCTTTTTA GCAATTGTTT TTGTATCCTT TTTGCCCTTG
120
AATATGTAAT CCATAAACTT ATGCAGGAAG TGCCTCGTGC CGAATTCGGC ACGAGAATCA
180
CTGACCTTCA AATATTTATT CCAATTCTAA TATCTCTACT CGCTGTCTAC CTGATTTTTC
240
AGTGGCGAAC CAACTTGACA GGGTTGGACA TGGCCAACAG CAGCAAGATT CTGATTATTG
300
GAGGAACAGG CTACATTGGT CGTCATATA CCAAAGCCAG CCTTGCTCTT GGTATCCCA
360
CATTCCTTCT TGTCAGAGAG ACCTCCGCTT CTAATCCTGA GAAGGCTAAG CTTCTGGAAT
420
CCTTCAAGGC CTCAGGTGCT ATTATACTCC ATGGATCTTT GGAGGACCAT GCAAGTCTTG
480
TGGAGGCAAT CAAGAAAGTT GATGTAGTTA TCTCGGCTGT CAAGGGACCA CAGCTGACGG
540
ATCAAACAGG ATATTTATCC AGGGTATTTA AAGGGAGGTT GGAACCCATC AAGAAGGGTT
600
TTGGCCAA
608

(2) INFORMATION FOR SEQ ID NO:71:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 1474 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:71:

GAATTCGGCA CGAGAAAACG TCCATAGCTT CCTTSCCAAC TGCAAGCAAT ACAGTACAAG
60
AGCCAGACGA TCGAATCCTG TGAAGTGGTT CTGAAGTGAT GGAAGGCTTG GAATCTGAAG
120

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AAACTGTTAC AGGATATGCA GCTCGGGACT CCAGTGGGCA CTTGTCCCTT TACACTTACA
180
ATCTCAGAAA GAAAGGACCT GAGGATGTAA TTGTAAAGGT CATTACTGTC GGAATCTGCC
240
ACTCTGATTT AGTTCAAATG CGTAATGAAA TGGACATGTC TCATTACCCA ATGGTCCCTG
300
GGCATGAAGT GGTGGGGATT GTAACAGAGA TTGGCAGCGA GGTGAGGAAA TTCAAAGTGG
360
GAGAGCATGT AGGGGTTGGT TGCATTGTTG GGTCTCTGCG CAGTTGCGGT AATTGCAATC
420
AGAGCATGGA ACAATACTGC AGCAAGAGGA TTTGGACCTA CAATGATGTC AACCATGACG
480
GCACACCTAC TCAGGGCGGA TTTGCAAGCA GTATGGTGGT TGATCAGATG TTTGTGGTTC
540
GAATCCCGGA GAATCTTCCT CTGGAACAAG CGGCCCTCTT TTTATGTGCA GGGGTTACAG
600
TTTTCAGCCC AATGAAGCAT TTGCCCATGA CAGAGCCCGG GAAGAAATGT GGGATTTTGG
660
GTTTAGGAGG CGTGGGGCAC ATGGGTGTCA AGATTGCCAA AGCCTTTGSA CTCACGTCGA
720
CGTTATCAG TTCGTCTGAT AAAAAGAAAAG AAGAAGCCAT GGAAGTCCTC GCGCCCGATG
780
CTTATCTTGT TAGCAAGGAT ACTGAAAAGA TGATGGAAGC AGCAGAGAGC CTAGATTACA
840
TAATGGACAC CATTCCAGTT GCTCATCCTC TGGAAACCATA TCTTGGCCTT CTGAAGACAA
900
ATGGAAAGCT AGTGATGCTG GGCCTTGTTC CAGAGCCCTT GCACTTCGTG ACTCCTCTCT
960
TAATACTTGG GAGAAGGAGC ATAGCTGGAA GTTTCATTGG CAGCATGGAG GAAACACAGG
1020
AAACTCTAGA TTTCTGTGCA GAGAAGAAGG TATCATCGAT GATTGAGGTT GTGGGCCTGG
1080
ACTACATCAA CACGGCCATG GAAAGGTTGG AGAAGAACGA TGTCCGTTAC AGATTGTGTTG
1140
TGGATGTTGC TAGAAGCAAG TTGGATAATT AGTCTGCAAT CAATCAATCA GATCAATGCC
1200
TGCATGCAAG ATGAATAGAT CTGGACTAGT AGCTTAACAT GAAAGGGAAA TTAAATTTTT
1260
ATTTAGGAAC TCGATACTGG TTTTGTGTTAC TTTAGTTTAG CTTTGTGAG GTTGAAACAA
1320
TTCAGATGTT TTTTAACTT GTATATGTAA AGATCAATTT CTCGTGACAG TAAATAATAA
1380
TCCAATGTCT TCTGCCAAAT TAATATATGT ATTCTGATTT TTATATGAAA AAAAAAAAAA
1440
AAAAAAAAAA AAAAAAAAAA AAAAAAAAAA AAAAA
1474

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(2) INFORMATION FOR SEQ ID NO:72:

(1) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 1038 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(x1) SEQUENCE DESCRIPTION: SEQ ID NO:72:

```

GAATTCGGCA CGAGAGAGGG TTATATATCT TGATTCTGAC CTGATTGTCT TCGACGACAT
60
TGCCAAGCTC TGGGCCACGG ATTTGGAATC TCGTGTCTCT GGGGCAACAG ACTACTGCAA
120
GGCGAATTTT ACAAAGTATT TCACCGATAA TTTCTGGTGG GATCCCGCAT TATCCAAGAC
180
CTTTGAGGGA AAAAAACCTT GCTACTTCAA CACAGGCGTA ATGGTGATCG ATCTTGAAAA
240

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ATGGCGGGCA GGGGAATTCA CAAGAAAGAT CGAAATCTCG ATGGACATAC AGAAGGAACG
 300
 CCGTATCTAT GAGCTCGGAT CATTACCCCC ATTTTACTG GTATTGCTG GTTGSTTAA
 360
 GCAAGTCGAT CATCGTTGGA ATCAGCACGG TTTAGGCGGA GATAATTTGC AAGGCCCTTG
 420
 CCGAGATCTT CACCCTGGAC CTGTCAGTTT GTTGCAATGG AGTGGTAAGG CCAAACCTTG
 480
 GCTACGCCTG GAATGCCAAG CGGACTTGCC CTCTGGATAC TTTATGGGCT CTTATGATC
 540
 TTTATCGATC AACGTATTAC CTAAATGGGT GAGAGAGCCT CTCTCTCGG GTTGCTTTTT
 600
 ATCGAATTAA ACCTGATTTG ATAAAATGCC AAATAGAACT TTACGCCTAT GCATCTTTCA
 660
 GTTTTGAATT TCAATTCTGG TAACGAATAG AAGAAAACAA TAGCACAGCC ACAGGCAGGA
 720
 CAAATCCATC ATGAGGGACC AATCGTTTGA ATTTAGTATT AATAAGGTTG TTCCATATAA
 780
 CGCCTGTGAA GAATGATATT GTGGACTGAT CTATTTATAT TTGTAAGTGC ATGCCATCCT
 840
 CAGCCAGCAG AGAGGCAAGC AATGCCGCTG CAAGTCATGT AGGGAGGGCG TTGTGAAGTC
 900
 AATTTTCGGC GACTGTACAG CATGTAAAT TTTGGAACAT TAATATCATT ATGATAAGTT
 960
 CCTGAACCAA CAACTGTATA ATACCTTATA AATGTATCTG CAACTCCATT TTTGCATAAA
 1020
 AAAAAAAAAA AAAAAAAAAA
 1038

(2) INFORMATION FOR SEQ ID NO:73:

(1) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 372 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(x1) SEQUENCE DESCRIPTION: SEQ ID NO:73:

CTAGGGGTCT TGGGGGGTTC CTGATGCCCA ATTGTTGCTG TGCTTGGCAT GAACCCAAAA
 60
 CATGCAAGAG ATCTGTAGTC AGTAGTCTTG TTGGATCTAT AGCTTTTAGA AAAGAGTCAC
 120
 GTCCTTTTAG GGTAACATCA TTCCAACCAT ATCCAGTTCC ACCACCGGCT ACACCTTCAA
 180
 CGGGAGGAGG AGCAAGATAT TCAGCATTGC TTTGGGCACC AGATGGATAG GCATTATTTT
 240
 CCATCGGAAT TCAGCCGAGC TCGCCCCCTC AGTCCAATCG TCGTGAAAAT CCTCAAAAT
 300
 TGGGCAATTC TGGCTCGAAA TCGCCAAATT ATGGGCTACA ACAGGATTAA AATTGCACAG
 360
 AAATCTGCCA GT
 372

(2) INFORMATION FOR SEQ ID NO:74:

(1) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 545 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(x1) SEQUENCE DESCRIPTION: SEQ ID NO:74:

AAAGAATTCC GCACGAGGGC AATCCGAGCC TAGCCACCA ACTTGGCAGC AAGGAGCACA
 60
 GGGAGTTGGC GAGAGAGCT GTTAGGAAAT CTTGCTATT GTTGAAAAAT GGGAGTCAG
 120
 CCAACAAGCC TTTGCTCCCT TTGGAGAAGA ATGCTTCCAA GGTCTTGT TTGAGGAACCC
 180
 ATCCTGATAA TCTGGGTTAT CAGTGTGGTG GATGGAGAT GGAATGGCAA GATTAAGTG
 240
 GAAACATAAC CGTAGGAAC ACAAATCTGG AAGCTATCAA ACTAGCTGTG AGCCCTCTA
 300
 CTGAAGTGGT TTATGAGCAA AATCCAGATG CTAATATGT CAAAGGACAA GGTCTTCTAT
 360
 ATGCCATTGT GGTGTGGGT GAGGCACCAT ACGCAGAAAC GTTGGAGAC ATCTTAATT
 420
 TGACCATTCC CCTAGGCGGA GGGGACACGA TTAAGACGGT CTGTGGCTCC TTGAAATGCC
 480
 TTGTAATCTT GATATCTGGA AGGCCACTTG TTATGAACC TTATCTCCA TTGTTGGATC
 540
 GTTTT
 545

(2) INFORMATION FOR SEQ ID NO:75:

(1) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 463 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(x1) SEQUENCE DESCRIPTION: SEQ ID NO:75:

GCAGGTCGAC ACTAGTGGAT CCAAAGAATT CGGCACGAGA AAAAACAAT GTTAGCTAGC
 60
 CTAGTGATGA GCTTTACGTA TACCTGGCCT TTTATACATG GATCTGAGTT TTTATGCAGG
 120
 TGTAGAGCCT TTTGTTACTC TGTATCACTG GGAATTGCCA CAAGCTCTGG AGGACGAATA
 180
 CGGTGGATTT CGTAGCAAAA AAGTTGTGGA TGACTTTGGC ATATTCTCAG AAGAATGCTT
 240
 TCGTGCTTTT GGAGACCGTG TGAAGTACTG GGTAAGTGT AACGAACCGT TGATCTCTC
 300
 ATATTTTTCT TACGATGTGG GGCTTCACGC ACCGGGGCCG TGTTCGCCTG GATTTGGAAA
 360
 CTGCACTGCG GGAAATTCAG CGACAGAGCC TTATATTGTA GGCATAACA TGCTTCTTGC
 420
 ACATAGTACC GCTGTAAAAA ATATATAGCA TAAATACCA GGG
 463

(2) INFORMATION FOR SEQ ID NO:76:

(1) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 435 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(x1) SEQUENCE DESCRIPTION: SEQ ID NO:76:

ACACTAGTGG ATCCAAAGAA TTGGGCACGA GGCTACCATC TTCCCTCATA ATATTGGGCT
 60
 TGGAGCTACC AGGGATCCTG ATCTGGCTAG AAGAATAGGG GCTGCTACGG CTTTGGAAAT
 120
 TCGAGCTACT GGCATTCAAT ACACATTTGC TCCATGTGTT GCTGTTTGCA GAGATCCTCG
 180

ATGGGGCCCG TGCTATGAGA GGTACAGTGA GGATCCAAA ATTCTCAAGG TCATGACTGA
 240
 GATTATCGTT GGCCTGCAAG GGAATCCTCC TGCTAATTCT ACAAAGGGG GGCCTTTTAT
 300
 AGCTGGACAG TCAATGTTG CAGCTTGTGC TAAGCATTCT GTGGTTATG CTGGAACAC
 360
 CAAAGGTATC GATGAGAATA ATACTGTTAT CAATATCAA GGGTTATTTC AACATTCCAA
 420
 ATTACCCCCA ATTTT
 435

(2) INFORMATION FOR SEQ ID NO:77:

(1) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 451 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(X1) SEQUENCE DESCRIPTION: SEQ ID NO:77:

GAATTCGGCA CGAGCCTAGA ATTCTATGGT GAAATTTGT GGGACAAGGC TSCCCAAGTT
 60
 TACAAAGGAA CAGTCCCAA TGSTTAAAGG TTCAATAGAC TATCTAGGCG TTAACCAATA
 120
 CACTGCTTAT TACATGATG ATCCTAAACA ACCTAAACAA AATGTAACAG ATTACGAGC
 180
 TGGACTGGAA TACAGGCTTT GCATATGCTC GCAATGGAST GCCTATTGGA CCAAGGGGGA
 240
 ACTCCAATTG GCTTTACATT GTGCCTTGGG GTCTATACAA GGCCGTCACA TACGTAAPAG
 300
 AACACTATGG AAATCCAACAT ATGATTCTCT CTGAAAATGG AATGGACGAC CTGGAAACGT
 360
 GACACTTCCA GCAGGACTGC ATGATACCAT CAGGGGTAAC TACTATAAAA GCTATTTGCA
 420
 AAATTTGATT AATGCACSTG AATGACCGGG G
 451

(2) INFORMATION FOR SEQ ID NO:78:

(1) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 374 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(X1) SEQUENCE DESCRIPTION: SEQ ID NO:78:

CTGCTCTGCA AGCAGTACTA TGCACAGCAA GGCCTGCTTA ACTGAAAACA GAGCGCTGAG
 60
 CTTGAGGAAA CGCTCAAGCA TTGCTGAGGC CACCGTTTAT CTAAATAGCG CAACATAGGG
 120
 CTTGAGAAA ATGGCAATGG CACAAGCATT CAGAGGCCGT GTCTTGCAAG CTGCCCGTTT
 180
 GCTCCGCCCG AACATTCTGC CGGAGGATAA AAGCTTTGGA TCCGCTGCTT CTCCTAGAGC
 240
 AGCTCTTAGC CTGCTCTCAT CAAAAGCCTT CATCTCTTTC TCTGTTGAAC GGCATCGGCT
 300
 AGCTGCTACA AATTCAACAA TTGTGTTGCA ATCTCGAAAC TTTTCTGCAA AAGGTAAAAA
 360
 GACAGGACAA TCTG
 374

(2) INFORMATION FOR SEQ ID NO:79:

(1) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 457 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(x1) SEQUENCE DESCRIPTION: SEQ ID NO:79:

GAAGAATGGA AGAGATTAAT GGTGATAACG CAGTAAGGAG GAGCTGCTTT COTCCAGGTT
60
TCATGTTTGG GATAGCAACT TGTGCTTATC AGTGTGAAGG AGCTGCCAAC GAAGGTGGAA
120
AAGGCCCAAG CATCTGGGAC TCATTTTCAC GAACACCAGG CAAAATTCTT GATGGAAGCA
180
ACGGTGATGT AGCAGTGGAT CAGTATCATC GTTATAAGGC AGATGTAAAA CTGATGAAAG
240
ATATGGGCCT GGCTACCTAC AGATTCTTGA TTTCATGCCC TCGTATATTT CCAAAGGGAA
300
AAGGAGAGAT CAATGAGGAA GGAGTAGCCT ATTACAATAA COTCATCAAT GAACTCCTCC
360
AGAATGGAAT CCAAGCCTCT GTCAACTTTG TTCACTGGG ATACTCCCA GTCTCTGGA
420
GATGAATATG GCGGATTTCT GAGGCCAACC ATTGTGA
457

(2) INFORMATION FOR SEQ ID NO:80:

(1) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 346 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(x1) SEQUENCE DESCRIPTION: SEQ ID NO:80:

GGTGTGATGG CAGGAATTCC AGTCCTAAGG CCATTTTGCA TGTGTTTCTT TTCAGTCTAC
60
ATGCTGCACA TTGTAGCTCC AGTAGCTTCA CCAAGGCTAG GTAGAAGCAG CTTCCTAAGG
120
GGTTTCAAAT TTGGTCCAGG GTCATCTGCT TATCAGGCGG AAGGAGCTGC TCATGAGGGT
180
GGCAAAGGCC CAAGCATTTG GGATACATTC TCCCACACTC CAGGTAAAAT CGCTGATGGG
240
AATATTGGGA TGTTGCAGTA GATCAATACC ACCGTTATAA GGAAGATGTG CAGCTTCTCA
300
AATACATGGG AATGGACGTC TATCGTTTCT CTATCTCCTG GTCACG
346

(2) INFORMATION FOR SEQ ID NO:81:

(1) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 957 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(x1) SEQUENCE DESCRIPTION: SEQ ID NO:81:

GAATTCGGCA CGAGAAAGCC CTAGAATTTT TTCAGCATGC TATCACAGCC CCAGCGACAA
60
CTTAACTCC AATAACTGTG GAAGCGTACA AAAAGTTTGT CTAAGTTTCT CTCATTGAGA
120

CTGGTCAGGT TCCAGCATTT CCAAAATACA CACCTGCTGT TGTCCAAAGA AATTGGAAT
 180
 CTTGCACTCA GCCCTACATT GATTTAGCAA ACAACTACAG TAGTGGGAAA ATTTCTGTAT
 240
 TGGAAGCTTG TGTCAACACG AACACAGAGA AGTTCAAGAA TGATAGTAAT TTGGGGTTAG
 300
 TCAAGCAAGT TTTGTGATCT CTTTATAAAC GGAATATTCA GAGATTGACA CAGACATATC
 360
 TGACCCTCTC TCTTCAAGAC ATAGCAAGTA CGGTACAGTT GGAGACTGCT AAGCAGGCTG
 420
 AACTCCATGT TCTGCAGATG ATTCAAGATG GTGAGATTTT TGCAACCATA AATCAGAAAG
 480
 ATGGGATGGT GAGCTTCAAT GAGGATCCTG AACAGTACAA AACATGTCAG ATGACTGAAT
 540
 ATATAGATAC TGCAATTGGG AGAATCATGG CACTATCAAA GAAGCTCACC ACAGTAGATG
 600
 AGCAGATTTG GTGTGATCAT TCCTACCTGA GTAAGGTGGG GAGAGAGCGT TCAAGATTTG
 660
 ACATAGATGA TTTTGATACT GTTCCCCAGA AGTTCACAAA TATGTAACAA ATGATGTAAA
 720
 TCATCTTCAA GACTCGCTTA TATTCAATTAC TTTCTATGTG AATTGATAGT CTGTTAACAA
 780
 TAGTACTGTE GCTGAGTCCA GAAAGGATCT CTCGGTATTA TCACTTGACA TGCCATCATA
 840
 AAAATCTCAA ATTTCTCGAT GTCTAGTCTT GATTTTGATT ATGAATGCCA CTTTGTAGTG
 900
 TGACATTTGA GCACCTCGAG TGAACACAA AGTTGCATGT TAAAAAATAA AAAAAAA
 957

(2) INFORMATION FOR SEQ ID NO:82:

(1) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 489 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(x1) SEQUENCE DESCRIPTION: SEQ ID NO:82:

GCAGGTGAG ACTAGTGGAT CCAAGAATT CGGCACGAGA TAAGACTAAT TTTCCAGACA
 60
 ATCCTCCATT CCCATTCAAT TACACTGGTA CTCCACCCAA TAATACACAG GCTGTGAATG
 120
 GGACTAGAGT AAAAGTCCTT CCCTTTAACA CAACTGTTCA ATTGATTCTT CAAGACACCA
 180
 GCATCTTCAG CACAGACAGC CACCCTGTCC ATCTCCATGG TTTCATTTC TTTGTGGTGG
 240
 GCCAAGGTGT TGGAACTAC AATGAATCAA CAGATGCACC AAATTTTAAC CTCATTGACC
 300
 CTGTGAGAG AAACACTGTG GGAGTTCCCA AAGGAGGTTG GGCTGCTATA AGATTTCTGT
 360
 CAGACAATCC AGGGGTTTGG TTCATGCACT GTCATTGGA GGTTCACACA TCGTGGGGAC
 420
 TGAAAATGCC GTGGGTAGTA AAGAACGGAA AAGGGCCCAT CGATTTTCCA CCCGGGTGGG
 480
 TACCAGTAA
 489

(2) INFORMATION FOR SEQ ID NO:83:

(1) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 471 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(x1) SEQUENCE DESCRIPTION: SEQ ID NO:83:

GAATTCGGCA CGAGAAAACC TTTTCAGACG AATGTTCTGA TGCTCGGCCG CGGCCAGACA
60
ACAGACATAC TTCTCACTGC CAATCAGGCT ACAGGTAGAT ACTACATGGC TGCTCGAGCA
120
TATTCCAACG GGCAAGGAGT TCCCTTCGAT AACACCACTA CCACTGCCAT TTTAGAATAC
180
GAGGGAAGCT CTAAGACTTC AACTCCAGTC ATGCCTAATC TTCCATTCTA TAACGACACC
240
AACAGTGCTA CTAGCTTCGC TAATGGTCTT AGAAGCTTGG GCTCACAAGA CCACCCAGTC
300
TTGGTTCCTC AGAGTGTGGA GGAGAATCTG TTCTACACCA TCGGTTGGG GTTGATCAAA
360
TGTCCGGGGC AGTCTTGTGG AGGTCCAACG GATCAAGATT TGCAGCAAGT ATGAATACAT
420
ATCATTTGTC CCGCAACCAC TTCTTCCAAT CCTTCAAGCT CAGCATTTTG G
471

(2) INFORMATION FOR SEQ ID NO:84:

(1) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 338 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(x1) SEQUENCE DESCRIPTION: SEQ ID NO:84:

GTTCCGGCACT GAGAGATCCA TTTCTTTCAA TGTTGAGACA GTGAGTAGTA TTAGTTTGAT
60
ATCTCTTTCA GGAATATATC GTGCTTGCAG GATCTTTAGT TTCTGCAACA ATGTGCTTGC
120
AATCAGTGCG TCTATCTTCT GCTCTCCTTG TTTTGCTACT AGCATTGTGT GCTTACTTAG
180
TTGCTGTAAC AAACGCAGAT GTCCACAATT ATACCTTCAT TATTAGAAAG AGACAGTTAC
240
CAGGCTATGC AATAAGCGTA TAATCGCCAC CGTCAATGGC AGCTACCAGG CCAACTATT
300
CATGTACGTC ATGGAGACGT TGTAAATTAT CAAAGCTT
338

(2) INFORMATION FOR SEQ ID NO:85:

(1) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 1229 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(x1) SEQUENCE DESCRIPTION: SEQ ID NO:85:

AGAGAAATAA TTATATTTGT AAATTTAAGT CTACGTTTAT TAAAAAATA CAACCCTAAA
60
TGCAGGAGAA AAAACAAGCA TGCTGTCTAC TGAAGCTTAC AAATCAAATC CCTGCGATAT
120
GTCTTTTCTG GTGCCGAATT CGGCACGAGA AGATCTTGGT TCGAGTCTCT CAGCTCTCTC
180
CAAAGGAATT TTGTGGGTCA TTTGCAGGTG AAGACACCAT GGTGAAGGCT TATCCCACCG
240
TAAGCGAGGA GTACAAGGCT GCCATTGACA AATGCAAGAG GAAGCTCCGA GCTCTCATTG
300

CAGAGAAGAA CTGTGCGCCG ATCATGSTT GATCGCATG GCACAGCGCT GGGACTTACG
 360
 ATGTCAAGAC CAAGACCGGA GGGCCCTTCG GGACGATGAG ATATGGGGCC GAGCTTGCCC
 420
 ACGGTGCTAA CASTGGTCTG GACATCGCAG TTAGGCTCCT GGAGCCAATC AAGGAACAGT
 480
 TCCCCATAAT CACCTATGCT GACCTTTATC AGTTGGCTGG TGTGGTGGCT GTTGAAGTGA
 540
 CCGGGGGAGC TGACATTCCG TTCCATCCTG GAAGAGAAGA CAAGCCTGAG CCTCCAGAAG
 600
 AAGGCCGCTT TCCTGATGCT AAAAAAGGAC CTGATCATCT GAGGGATGTT TTTGGTCACA
 660
 TGGGTTTGAA TGATAAGGAA ATTGTGGCCT TGTCTGGTGC CCACACCTTG GGGAGATGCC
 720
 ACAAGGAGAG ATCTGGTTTT GAAGGACCAT GGACCTCTAA CCCCCTTATC TTTGACAACT
 780
 CTTACTTCAC AGAGCTTGTS ACTGGAGAGA AGGAAGGCTT GCTTCAGTTG CCATCTGATA
 840
 AGGCACTGCT TCTGATCCT AGTTTTCGAG TTTATGTTCA GAAGTATGCA CAGGACGAAG
 900
 ACGCTTTCTT TGCTGACTAT GCGGAAGCTC ACCTGAAGCT TTCTGAACTT GGGTTTGCTG
 960
 ATGCGTAGAT TCATACCTTC TGCAGAGACA ATTCTTCTCT AGATAGCTTC GTTTTGTATT
 1020
 TCATCTAATC TTTTCGATTA TATAGTCACA TAGAAGTTGG TGTATGCGC CATAGTGATA
 1080
 CTTGAACCTA CATGTTTTTG AAAAGTATCG ATGTTCTTTA AAATGACAT TGAATACAAC
 1140
 ATTTTGGAAAT CTGGTTGTGT TCTATCAAGC GCATATTTTA ATCGAATGCT TCGTTCTCTG
 1200
 TAAAAAAAAA AATAAAATAA AAAAAAAAAA
 1229

(2) INFORMATION FOR SEQ ID NO:86:

- (1) SEQUENCE CHARACTERISTICS:
 (A) LENGTH: 1410 base pairs
 (B) TYPE: nucleic acid
 (C) STRANDEDNESS: single
 (D) TOPOLOGY: linear

(x1) SEQUENCE DESCRIPTION: SEQ ID NO:86:

GAAGATGGGG CTGTGGGTGG TGCTGGCTTT GCGGCTCACT GCGCACTATT GCAGTCTCAG
 60
 GCTTACAATG TGGTAAGTTC AAGCAATGCT ACTGGGAGTT ACAGTGAGAA TGGATTGGTG
 120
 ATGAATTACT ATGGGGACTC TTGCCCTCAG GCTGAAGAGA TCATTGCTGA ACAAGTACGC
 180
 CTGTTGTACA AAAGACACAA GAACACTGCA TTCTCATGGC TTAGAAATAT TTTCCATGAC
 240
 TGTGCTGTGG AGTCATGTGA TGCATCGCTT CTGTTGGACT CAACAAGGAA CAGCATATCA
 300
 GAAAAGGACA CTGACAGGAG CTCGGCCTC CGCAACTTTA GGTATTTGGA TACCATCAAG
 360
 GAAGCCGTGG AGAGGGAGTG CCCCAGGGTC GTTCTCTGTG CAGATATACT CGTTCTCTCT
 420
 GCCAGAGATG GCGTTGTATC GTTGGGAGGA CCATACATTC CCTGAAGAC GGGAGAAGA
 480
 GATGGACGGA AGAGCAGAGC AGATGTGGTG GAGAATTACC TGGCCGATCA CAATGAGAGC
 540
 ATCTCCACTG TTCTGTCTCG CTTCAAAGCC ATGGGAATCG ACACCCGTGG GGTGTTGCA
 600
 CTGCTGGGGG CTCACAGCGT GGGGAGGACT CACTGCGTGA AGCTGTTGCA CAGGCTGTAC
 660

720 CCGGAAGTAG ATCCGACACT GGACCTCTSSG CACSTGAGG ACATGAGCA GAAGTGGGGG
 780 GACGCGATCC CCAACCCGAA GGCAGTGCAG TATGTGCGGA AGGACTGGGG AAGGCTATG
 840 AAGCTGGACA ACAACTACTA CCGTAACCTG ATGAACAACA AGGGGCTCCT AATAGTGGAC
 900 CAGCAACTGT ATGCAGATTC GAGGACCAGG CCGTATGTGA AAPAGATGGC AAAAAGGCG
 960 GAATACTTCT TCAAATACTT CTCCCGGGGG UTCACCATCC TGTGTGAGAA CAATCCTCTC
 1020 ACCGGGGCTC GAGGAGAAAT CCGTCGGCAG TGCTCGCTCA AAAACAAATT GCACACAAA
 1080 AGCAAGCGTT GAGCGATAGC TCAATGCCCG AGTGGTGGGA GTGATAGCGT GATGCCACAG
 1140 TGGTGGGCAT TTCATATATA AATTGCACTT TGGGTTTTTA TTAGATAATC ATAATGGTGT
 1200 GGTGTGACTA TGGCCTGCGA ATCAGATGSA TGAACCAACA CCGAACCGTG GAACAGTAGG
 1260 CTTATTCCCT TATGTAAGCA GAACCTTTTA TTATAAGCAA AAAAGACAAT CTTCTCTCTT
 1320 ATTCTAGTAT AATTTTGTCA TCAGTTAAAG TTCTCATCTC GATAATAACT GGAACGGTA
 1380 AAATATGACA ACTACGTATC TTCTTTGGTC ATCTGATAAT AAGTGGAAAC GATAAATAT
 1410 GACAACCTACA TATATTCTTT AAAAAAAAAA

(2) INFORMATION FOR SEQ ID NO:97:

(1) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 687 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(x1) SEQUENCE DESCRIPTION: SEQ ID NO:97:

60 GTAGTTTCCT TTTACAACAA TCTCAGGTTT TGAATCTCAG AATAGTTGCG AAGGGAAGCG
 120 ATGACGAAGT ACGTGATCCT TAGCTGCATT GTGTGTTTCT TTCTATTTGT TTCTGGCTGC
 180 ATAATTTCTG TCAATGGATT AGTTCTCCAT GAAGATGATC TGTCAAAGCG TGTGCATGGG
 240 CTTTCGTGGA CATTTTATAA GGACAGTTGC CCGGACTTGA AGGCCATAGT GAAATCGGTA
 300 CTTGAGCCCG CGTTGGACGA AGATATCACT CAGGCGCGCAG CTTTCTTGAG ACTTCATTTC
 360 CATGACTGTT TTGTGCAGGG TTGCGATGGG TCCGTGTTCC TGACAGGAAC TAAAAGAAAC
 420 CCCAGTGAGC AACAGGCTCA GCCAAACTTA AACTAAGAG CCGGGGCCCT GCAGCTGATC
 480 GACGAAATTA AAACCGCTGT AGAAGCTAGC TGCAGTGGGG TTGTAACCTG TGCAGACATT
 540 CTGGCTTTGG CTGCTCGTGA CTCCTCCGCG TCAGGAGGGC CAAAATTTCG AGTACCACTT
 600 GGCGGCAGAG ATAGCCTAAA GTTTGCCAT CAATCCCTAG TTCTGCGCAA TATACCAACT
 660 CCAACTTTAA ATTTGACACA GGTGATGAAC ATTTTGGCT TCAAAAGATT CAGTTTGGCC
 687 GAAATGGTTG CTCTTCAGGT GGCACAC

(2) INFORMATION FOR SEQ ID NO:98:

(1) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 688 base pairs
 (B) TYPE: nucleic acid
 (C) STRANDEDNESS: single
 (D) TOPOLOGY: linear

(X1) SEQUENCE DESCRIPTION: SEQ ID NO:88:

GTAGTTTGGT TTTACAACAA CTTACAGGTT TTGAATCTCA GAATAGTTGC GAAAGGAAGC
 60
 GATGACGAAG TAGGTGATCG TTAGCTCCAT TGTATGTTTC TTTGTATTTG TTTCTGCGTG
 120
 CATAATTTCT GTCAATGGAT TAGTTGTCCA TGPAGATGAT CTGTCAAAGC TTGTGCAATGG
 180
 GCTTTGCGTG ACATTTTATA AGGACAGTTG CCGCGACTTG GAGGCCATAG TGAATCGGT
 240
 ACTTGAGGCG GCGTTGAGCG AAGATATCAC TCAGGCGGCA GGTTCGTGAG ACTTCATTTG
 300
 CATGACTGTT TTGTGCGAGG TTCCGATGGG TCGGTGTTGC TCACAGGAAC TAAAGAAAC
 360
 CCGCGAGTGA GCAACAGGCT CAGCGAAACT TAACACTAAG ACCCGGGGCC TTGAGCTGA
 420
 TCGAGCAAT TAAACCGGT CTAGAAGCTA GGTGCACTGG GGTGTAACT TGTGAGACA
 480
 TTGTGGCTTT GGTGCTGCT GACTCGCTG CTCAGGAGGC CCAAAATTTG CACTACCACT
 540
 TGGCGCGAGA GATAGCTAA AATTTGCCAG TCAATCGTA GTTCTCGCCA ATATACCAAC
 600
 TCCAACTTTA AATTTGACAC AGCTGATGAA CATTTTTGGC TCCAAAGGAT TCAGTTTGGC
 660
 CGAAATGCTT GGTCTTCAGG TGGCACAC
 688

Claims:

1. An isolated DNA sequence comprising a nucleotide sequence selected from the group consisting of
 - (a) sequences recited in SEQ ID NO: 3, 13, 16-70, 72-88;
 - (b) complements of the sequences recited in SEQ ID NO: 3, 13, 16-70, 72-88;
 - (c) reverse complements of the sequences recited in SEQ ID NO: 3, 13, 16-70, 72-88;
 - (d) reverse sequences of the sequences recited in SEQ ID NO: 3, 13, 16-70, 72-88 and
 - (e) sequences having at least about a 99% probability of being the same as a sequence of (a) - (d) as measured by computer algorithm FASTA.
2. A DNA construct comprising a DNA sequence according to claim 1.
3. A transgenic cell comprising a DNA construct according to claim 2.
4. A DNA construct comprising, in the 5'-3' direction:
 - (a) a gene promoter sequence,
 - (b) an open reading frame coding for at least a functional portion of an enzyme encoded by a nucleotide sequence selected from the group consisting of sequences recited in SEQ ID NO: 3, 13, 16-70, 72-88 and sequences having at least about a 99% probability of being the same as a sequence of SEQ ID NO: 3, 13, 16-70, 72-88 as measured by computer algorithm FASTA; and
 - (c) a gene termination sequence.
5. The DNA construct of claim 4 wherein the open reading frame is in a sense orientation.

6. The DNA construct of claim 4 wherein the open reading frame is in an antisense orientation.
7. The DNA construct of claim 4, wherein the gene promoter sequence and gene termination sequences are functional in a plant host.
8. The DNA construct of claim 4, wherein the gene promoter sequence provides for transcription in xylem.
9. The DNA construct of claim 4 further comprising a marker for identification of transformed cells.
10. A DNA construct comprising, in the 5'-3' direction:
 - (a) a gene promoter sequence.
 - (b) a non-coding region of a gene coding for an enzyme encoded by a nucleotide sequence selected from the group consisting of sequences recited in SEQ ID NO: 3, 13, 16-70, 72-88 and sequences having at least about a 99% probability of being the same as a sequence of SEQ ID NO: 3, 13, 16-70, 72-88 as measured by computer algorithm FASTA; and
 - (c) a gene termination sequence.
11. The DNA construct of claim 10 wherein the non-coding region is in a sense orientation.
12. The DNA construct of claim 10 wherein the non-coding region is in an antisense orientation.
13. The DNA construct of claim 10, wherein the gene promoter sequence and gene termination sequences are functional in a plant host.
14. The DNA construct of claim 10, wherein the gene promoter sequence provides for transcription in xylem.

15. A transgenic plant cell comprising a DNA construct, the DNA construct comprising, in the 5'-3' direction:
 - (a) a gene promoter sequence;
 - (b) an open reading frame coding for at least a functional portion of an enzyme encoded by a nucleotide sequence selected from the group consisting of sequences recited in SEQ ID NO: 3, 13, 16-70, 72-88 and sequences having at least about a 99% probability of being the same as a sequence of SEQ ID NO: 3, 13, 16-70, 72-88 as measured by computer algorithm FASTA; and
 - (c) a gene termination sequence.
16. The transgenic plant cell of claim 15 wherein the open reading frame is in a sense orientation.
17. The transgenic plant cell of claim 15 wherein the open reading frame is in an antisense orientation.
18. The transgenic plant cell of claim 15 wherein the DNA construct further comprises a marker for identification of transformed cells.
19. A plant comprising a transgenic plant cell according to claim 15, or fruit or seeds thereof.
20. The plant of claim 19 wherein the plant is a woody plant.
21. The plant of claim 20 wherein the plant is selected from the group consisting of eucalyptus and pine species.
22. A transgenic plant cell comprising a DNA construct, the DNA construct comprising, in the 5'-3' direction:
 - (a) a gene promoter sequence;

- (b) a non-coding region of a gene coding for an enzyme encoded by a nucleotide sequence selected from the group consisting of sequences recited in SEQ ID NO: 3, 13, 16-70, 72-88 and sequences having at least about a 99% probability of being the same as a sequence of SEQ ID NO: 3, 13, 16-70, 72-88 as measured by computer algorithm FASTA; and
 - (c) a gene termination sequence.
- 23. The transgenic plant cell of claim 22 wherein the non-coding region is in a sense orientation.
- 24. The transgenic plant cell of claim 22 wherein the non-coding region is in an antisense orientation.
- 25. A plant comprising a transgenic plant cell according to claim 22, or fruit or seeds thereof.
- 26. The plant of claim 25 wherein the plant is a woody plant.
- 27. The plant of claim 26, wherein the plant is selected from the group consisting of eucalyptus and pine species.
- 28. A method for modulating the lignin content of a plant comprising stably incorporating into the genome of the plant a DNA construct comprising, in the 5'-3' direction:
 - (a) a gene promoter sequence;
 - (b) an open reading frame coding for at least a functional portion of an enzyme encoded by a nucleotide sequence selected from the group consisting of sequences recited in SEQ ID NO: 3, 13, 16-70, 72-88 and sequences having at least about a 99% probability of being the same as a sequence of SEQ ID NO: 3, 13, 16-70, 72-88 as measured by computer algorithm FASTA; and
 - (c) a gene termination sequence.

29. The method of claim 28 wherein the plant is selected from the group consisting of eucalyptus and pine species.
30. The method of claim 28 wherein the open reading frame is in a sense orientation.
31. The method of claim 28 wherein the open reading frame is in an antisense orientation.
32. A method for modulating the lignin content of a plant comprising stably incorporating into the genome of the plant a DNA construct comprising, in the 5'-3' direction:
 - (a) a gene promoter sequence;
 - (b) a non-coding region of a gene coding for an enzyme encoded by a nucleotide sequence selected from the group consisting of sequences recited in SEQ ID NO: 3, 13, 16-70, 72-88 and sequences having at least about a 99% probability of being the same as a sequence of SEQ ID NO: 3, 13, 16-70, 72-88 as measured by computer algorithm FASTA; and
 - (c) a gene termination sequence.
33. The method of claim 32 wherein the non-coding region is in a sense orientation.
34. The method of claim 32 wherein the non-coding region is in an antisense orientation.
35. The method of claim 32 wherein the plant is a woody plant.
36. The method of claim 35, wherein the plant is selected from the group consisting of eucalyptus and pine species.
37. A method for producing a plant having altered lignin structure comprising:

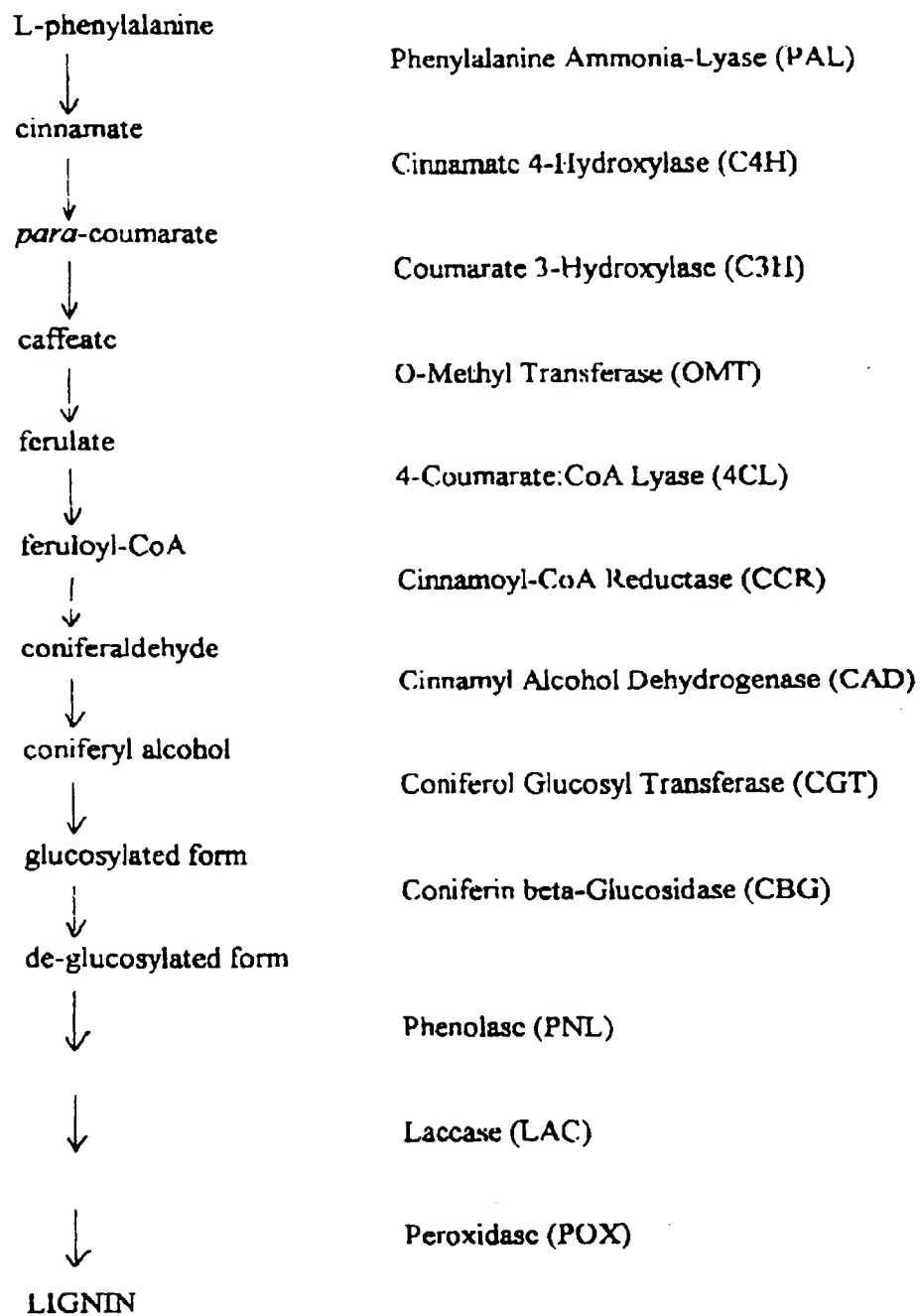
- (a) transforming a plant cell with a DNA construct comprising, in the 5'-3' direction, a gene promoter sequence, an open reading frame coding for at least a functional portion of an enzyme encoded by a nucleotide sequence selected from the group consisting of sequences recited in SEQ ID NO: 3, 13, 16-70, 72-88 and sequences having at least about a 99% probability of being the same as a sequence of SEQ ID NO: 3, 13, 16-70, 72-88 as measured by computer algorithm FASTA, and a gene termination sequence to provide a transgenic cell;
 - (b) cultivating the transgenic cell under conditions conducive to regeneration and mature plant growth.
38. The method of claim 37 wherein the open reading frame is in a sense orientation.
39. The method of claim 37 wherein the open reading frame is in an antisense orientation.
40. The method of claim 37 wherein the plant is a woody plant.
41. The method of claim 40 wherein the plant is selected from the group consisting of eucalyptus and pine species.
42. A method for producing a plant having altered lignin structure comprising:
- (a) transforming a plant cell with a DNA construct comprising, in the 5'-3' direction, a gene promoter sequence, a non-coding region of a gene coding for an enzyme encoded by a nucleotide sequence selected from the group consisting of sequences recited in SEQ ID NO: 3, 13, 16-70, 72-88 and sequences having at least about a 99% probability of being the same as a sequence of SEQ ID NO: 3, 13, 16-70, 72-88 as measured by computer algorithm FASTA, and a gene termination sequence to provide a transgenic cell;

- (b) cultivating the transgenic cell under conditions conducive to regeneration and mature plant growth.
- 43. The method of claim 42 wherein the non-coding region is in a sense orientation.
 - 44. The method of claim 42 wherein the non-coding region is in an antisense orientation.
 - 45. The method of claim 42 wherein the plant is a woody plant.
 - 46. The method of claim 45 wherein the plant is selected from the group consisting of eucalyptus and pine species.
 - 47. A method of modifying the activity of an enzyme in a plant comprising stably incorporating into the genome of the plant a DNA construct including
 - (a) a gene promoter sequence;
 - (b) an open reading frame coding for at least a functional portion of an enzyme encoded by a nucleotide sequence selected from the group consisting of sequences recited in SEQ ID NO: 3, 13, 16-70, 72-88 and sequences having at least about a 99% probability of being the same as a sequence of SEQ ID NO: 3, 13, 16-70, 72-88 as measured by computer algorithm FASTA; and
 - (c) a gene termination sequence.
 - 48. The method of claim 47 wherein the open reading frame is in a sense orientation.
 - 49. The method of claim 47 wherein the open reading frame is in an antisense orientation.
 - 50. A method of modifying the activity of an enzyme in a plant comprising stably incorporating into the genome of the plant a DNA construct including

- (a) a gene promoter sequence;
- (b) a non-coding region of a gene coding for an enzyme encoded by a nucleotide sequence selected from the group consisting of sequences recited in SEQ ID NO: 3, 13, 16-70, 72-88 and sequences having at least about a 99% probability of being the same as a sequence of SEQ ID NO: 3, 13, 16-70, 72-88 as measured by computer algorithm FASTA; and
- (c) a gene termination sequence.

- 51. The method of claim 50 wherein the non-coding region is in a sense orientation.
- 52. The method of claim 50 wherein the non-coding region is in an antisense orientation.
- 53. The method of claim 50 wherein the plant is a woody plant.
- 54. The method of claim 53 wherein the plant is selected from the group consisting of eucalyptus and pine species.

FIG. 1





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(21) International Application Number: PCT/NZ97/00112 (22) International Filing Date: 10 September 1997 (10.09.97) (30) Priority Data: 08/713,000 11 September 1996 (11.09.96) US (71) Applicants: GENESIS RESEARCH & DEVELOPMENT CORPORATION LIMITED [NZ/NZ]; 1 Fox Street, Parnell, Auckland (NZ). FLETCHER CHALLENGE FORESTS LIMITED [NZ/NZ]; 585 Great South Road, Penrose, Auckland (NZ). (72) Inventors: BLOKSBERG, Leonard, Nathan; 5A Korau Road, Greenlane, Auckland (NZ). GRIERSON, Alistair, Wallace; 1/24 Medina Place, Bucklands Beach, Auckland (NZ). HAVUKKALA, Ilkka, Jaakko; 3/121 Atkin Avenue, Mission Bay, Auckland (NZ). (74) Agents: BENNETT, Michael, Roy et al.; Russell McVeagh West-Walker, The Todd Building, Level 5, 171-177 Lambton Quay, Wellington 6001 (NZ).		(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ZW, ARIPO patent (GH, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG). Published <i>With international search report.</i> <i>Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i> (88) Date of publication of the international search report: 20 August 1998 (20.08.98)
(54) Title: MATERIALS AND METHODS FOR THE MODIFICATION OF PLANT LIGNIN CONTENT (57) Abstract Novel isolated DNA sequences associated with the lignin biosynthetic pathway are provided, together with DNA constructs including such sequences. Methods for the modulation of lignin content in plants are also disclosed, the methods comprising incorporating one or more of the inventive DNA sequences or a sequence complementary to an inventive DNA sequence into the genome of a plant.		

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A. CLASSIFICATION OF SUBJECT MATTER

IPC 6 C12N15/53 C12N15/54 C12N15/52 C12N15/60 C12N15/82
A01H5/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 C12N A01H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. Claims: 1-54 all partially

Isolated DNA sequences of ID nos 3,17,48,49 encoding cinnamate 4-hydroxylase (C4H), plant expression constructs incorporating said sequences, methods to modulate lignin content, structure, and enzyme activity in plants using said constructs, and transgenic plants and plant cells containing them.

2. Claims: 1-54 partially

Isolated DNA sequences of ID nos 18,50-52 encoding coumarate 3-hydroxylase (C3H), plant expression constructs incorporating said sequences, methods to modulate lignin content, structure, and enzyme activity in plants using said constructs, and transgenic plants and plant cells containing them.

3. Claims: 1-54 all partially

Isolated DNA sequences of ID nos 35,36,81 encoding phenolase (PNL), plant expression constructs incorporating said sequences, methods to modulate lignin content, structure, and enzyme activity in plants, transgenic plants and plant cells containing said constructs.

4. Claims: 1-54 all partially

Isolated DNA sequences of ID nos 22-25,53-55 encoding O-methyl transferase (OMT), plant expression constructs incorporating said sequences, methods to modulate lignin content, structure, and enzyme activity in plants using said constructs, and transgenic plants and plant cells containing them.

5. Claims: 1-54 all partially

Isolated DNA sequence of ID no 30, encoding cinnamyl alcohol dehydrogenase (CAD), plant expression constructs incorporating said sequences, methods to modulate lignin content, structure, and enzyme activity in plants using said constructs, and transgenic plants and plant cells containing them.

6. Claims: 1-54 all partially

Isolated DNA sequences of ID nos 26-29,58-70 encoding

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Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☒ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☒ The additional search fees were accompanied by the applicant's protest.
- ☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

12. Claims: 1-54 all partially

Isolated DNA sequences of ID nos 13,42-44,85-88 encoding peroxidase (POX), plant expression constructs incorporating said sequences, methods to modulate lignin content, structure, and enzyme activity in plants using said constructs, and transgenic plants and plant cells containing them.

13. Claims: 1-54 all partially

Isolated DNA sequences of ID nos 19-21 encoding ferulate-5-hydroxylase (F5H), plant expression constructs incorporating said sequences, methods to modulate lignin content, structure, and enzyme activity in plants using said constructs, and transgenic plants and plant cells containing them.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

cinnamoyl-CoA reductase (CCR) ,plant expression constructs incorporating said sequences, methods to modulate lignin content, structure, and enzyme activity in plants using said constructs,and transgenic plants and plant cells containing them.

7. Claims: 1-54 all partially

Isolated DNA sequences of ID nos 16,45-47 encoding phenylalanine ammonia lyase (PAL),plant expression constructs incorporating said sequences, methods to modulate lignin content, structure, and enzyme activity in plants using said constructs,and transgenic plants and plant cells containing them.

8. Claims: 1-54 all partially

Isolated DNA sequences of ID nos 56,57 encoding 4-coumarate:CoA ligase (4CL),plant expression constructs incorporating said sequences, methods to modulate lignin content, structure, and enzyme activity in plants using said constructs,and transgenic plants and plant cells containing them.

9. Claims: 1-54 all partially

Isolated DNA sequences of ID nos 31-33,72 encoding coniferol glucosyl transferase (CGT),plant expression constructs incorporating said sequences, methods to modulate lignin content, structure, and enzyme activity in plants using said constructs,and transgenic plants and plant cells containing them.

10. Claims: 1-54 all partially

Isolated DNA sequences of ID nos 34,73-80 encoding coniferin beta-glucosidase (CBG) ,plant expression constructs incorporating said sequences, methods to modulate lignin content, structure, and enzyme activity in plants using said constructs,and transgenic plants and plant cells containing them.

11. Claims: 1-54 all partially

Isolated DNA sequences of ID nos 37-41,82-84 encoding laccase (LAC) ,plant expression constructs incorporating said sequences, methods to modulate lignin content, structure, and enzyme activity in plants using said constructs,and transgenic plants and plant cells containing them.